PROCEEDINGS OF THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

VOLUME 25 JULY, 1958 NUMBER 2

THIS ISSUE OF THE PROCEEDINGS IS DEDICATED TO THE LATE

Edward George Reinhard

Many of us were acquainted with Dr. Reinhard's numerous contributions to the activities of the Helminthological Society of Washington, but few of us realize how extensive and varied his interests were, and what broadness and depth of outlook characterized all his work.

Doctor Reinhard was well prepared for his life in education and research by the training in classical studies he received at the College of St. Andrew from 1918 to 1920, and in the liberal arts at Woodstock College from 1920 to 1923. Even during his college days a more than cursory interest in zoology moved him to a study of the solitary wasp. As early as 1922 he related his observations to the Entomological Society of Washington. Greatly impressed by his presentation, Leland O. Howard, the eminent entomologist, urged the young student to publish not only his findings as individual scientific papers, but also in book form. This book, The Witchery of Wasps, has all the charm of Fabre's writings yet is characterized by Reinhard's own close observation and ingenious experiments, and by the literary finish of his presentation. Even in this early period of his scholarly career Doctor Reinhard's interest in parasitology was foreshadowed by a paper on the parasitic wasp *Nysson hoplisivora.*

Doctor Reinhard began his teaching career when, after a year at Fordham University, he became instructor in biology at Canisius College. He held this post for a year, from 1924 to 1925, and then spent two years as assistant biologist at the Buffalo Museum of Science.

In 1927 he began graduate work leading to a Doctor of Philosophy degree at the University of Minnesota, where he concentrated in limnology and entomology. During this period he was Associate Biologist working with a group established by the Minnesota Department of Health in 1928 to study stream pollution of the Upper Mississippi River. That Doctor Reinhard was primarily interested in basic, fundamental problems in biology became very evident now. It was clear to him that a great amount of information had been collected which had no bearing directly on the problem of stream pollution, but which, it seemed to him, could well be applied to a study of certain more fundamental ecological questions about the microscopic life of the river. This approach he continued as an area of his personal research, and published a monograph on the plankton ecology of the Upper Mississippi, from Minneapolis to Winona, in 1931.

It was evident by this time that he possessed not only a remarkable aptitude for research, but also that his interests in biology were unusually broad and varied, and that he could write with scholarly precision or with the liter-

ary skill necessary to engross and hold those not professionally interested in biology. It was because of these qualities that he was appointed biology editor of Compton's Encyclopedia. He held this post from 1930 to 1933. He was, however, destined to return to the academic life of a teacher that he had first sampled in 1924. He became associate professor of biology at Saint Thomas College (now the University of Scranton) in 1933, and served as head of the department at the same university from 1935 to 1940. During a part of this same time, from 1936 to 1941, Doctor Reinhard was instructor in charge of a course in marine invertebrates at the University of Maine Marine Laboratory at Lamoine.

During the last 18 years, since 1940, Doctor Reinhard has been head of the biology department at The Catholic University of America in Washington, D. C., where in 1945 he attained the rank of professor. It was here that his broad interests in biology, his concern with basic problems in the science, and his remarkable ability to help and inspire both the students and his faculty matured and brought forth fruit. He taught effectively courses in Invertebrate Zoology, Genetics, and Parasitic Arthropods. He helped many graduate students towards a fruitful research and teaching career in biology, and through the members of his faculty, was responsible for the contributions and careers of many more. His understanding and his interest in the research areas of all the members of the biology faculty at Catholic University developed in that body a remarkable unity of effort and purpose.

Doctor Reinhard's scholarly production continued unabated during his tenure at Catholic University. His plankton studies were maintained since his days at the University of Minnesota. He also produced papers on the Protozoa, the Acanthocephala, the Protochordata, and other phyla.

But the work which he found most absorbing was that on parasitic crustacea, the Isopoda and the Rhizocephala. It was his efforts here that most evidently carried the stamp of his attitudes and convictions about biological research. He realized that often significant problems in the various fields of biology are relegated to the sidelines simply because they do not fall within the province of any well-established division of a field. He felt a number of such problems existed in parasitology. He believed firmly that research done by zoologists in these fringe areas should be brought to the attention of parasitologists, for he was convinced both groups could be mutually benefited. The problem of parasitic castration, especially as it affects the crustacea, was one such problem which Doctor Reinhard pursued and on which he was an authority.

Another effort marked his engagement in little known areas of biology specifically because he considered these fundamentally as significant as the popular problems. This was his involvement in the controversy concerning sex determinism in the Bopyridae, a family of isopod crustaceans, sub-order Epicaridea. He experimented with *Stegophryxus hyptius* Thompson, an ectoparasite on the abdomen of a hermit crab, which seeks the definitive host as a cryptoniscus larva. He found that the free swimming cryptonisci are sexually undifferentiated and sexually undetermined. Differentiation followed fixation and was dependent on environmental factors. In the course of this work he also described a new genus and species of parasitic isopods of the family Entoniscidae.

Yet one more effort on Doctor Reinhard's part to incorporate the little known but potentially significant into the body of biology must be mentioned. The parasitic barnacles of the order Rhizocephala had received very limited

attention in North America. He entered this field, and made the first and still the only studies of the life history and host-parasite relationship of these animals for this continent. He did pioneer work on the taxonomy of these parasites not only from the Atlantic Coast, the Gulf of Mexico, and the Caribbean Sea but also from the Pacific Northwest. His name is associated with the identification of most of the Rhizocephala in the United States National Museum. An interesting and revealing sequence of events took place in connection with his work on the Rhizocephala. Doctor Reinhard named a species after Doctor Hilbrand Boschma, world authority on the Rhizocephala and Director of the Leiden Museum of Natural History in Holland; thereafter, in 1955, Doctor Boschma named a new species *Sacculina reinhardi;* finally shortly before his death Doctor Reinhard named a genus after Doctor Boschma.

His awareness of the many threads that have been used to spin the fabric of biology, and his deep appreciation of the science as a thoroughly human and personal thing for the investigator is shown by the interest which absorbed him in the months before his death. Doctor Reinhard wrote: "When a scientific achievement is stripped of its genealogical record and historical background it becomes an impersonal thing, without face, voice or spirit. Thus devitalized, its worth as knowledge is not impaired, but, lacking the human touch, it loses much of its power to rouse interest and inspire emulation." With these opening remarks he began a series of articles, only two of which were destined to be completed, Landmarks of Parasitology I and II, on the history of our knowledge of the life cycle of the liver fluke and trichina. These two works, the result of astonishingly meticulous search for even the least significant among the founders of parasitology, have themselves been called landmarks in modern zoological literature.

Doctor Reinhard's keen sense of the co-workers in the science and his desire to help them and be helped is reflected by the list of learned societies of which he was a member. These included the Society of Sigma Xi, Gamma Alpha, the American Association for the Advancement of Science, the Limnological Society of America, the Genetics Society of America, the American Society of Zoologists, the Washington Academy of Science, the American Society of Parasitologists, and the Catholic Commission on Intellectual and Cultural Affairs.

He was a member of and took very active part in the affairs of the Helminthological Society of Washington. He was its secretary in 1947 and served as vice-president in 1948 and president in 1953. He served the same Society as a member of the Editorial Committee of its Proceedings for ten years, and was Editor from 1948 to 1951.

It must not be forgotten that during a lifetime given to his own scholarship and to the development of scholarship in young people from all parts of the country, indeed, the world, Doctor Reinhard shared his remarkable qualities with his family. His wife, his son Gregor, now a junior in college, his daughter Joan, a freshman, and Geoffrey, just completing his junior high school studies, must have done much to reinforce in Doctor Reinhard his noble qualities and were themselves the fortunate objects of his affection and devotion.

Doctor Reinhard's death ended a long and intensive vocation of teaching and research. Without unnecessary comparison, I believe he stood comfortably with the leading zoologists of the world. The Reverend Doctor Joseph B. McAllister, who spoke the eulogy, paid to Doctor Reinhard, in the

name of The Catholic University of America, this tribute:

"If you were to ask any one of the close associates of our departed friend what single virtue was most prominent in his life I feel sure each would reply that it was Dr. Reinhard's unfailing charity towards all. No one knows this better than those of us who worked with Dr. Reinhard. From the time he came to the University to be Head of its Department of Biology, 18 years ago, down to the very last, Doctor Reinhard proved himself much more concerned about his family and the University, his faculty colleagues and the students of his department than about himself. . . .

"The University has lost its outstanding scientist in the field of biology. But even more than that the scientific world has lost a distinguished scholar; and Catholic education, a man of utter devotion and rare qualities. . . .

"Doctor Reinhard was not an ivory tower academician. Learned as he was, and involved as he was in research, he never lost his human qualities of winning the affection, and stimulating the interest of his students, whether they were graduates or undergraduates. . . .

"He was learned and scholarly. But the secret of his outstanding success in building up a remarkably unified departmental faculty was his charity. Although his colleagues had to acknowledge his productive scholarship (he published nearly 50 learned papers), they sought him out mainly because they knew that in his charity he would bring to their problems not only a scholar's understanding but a Christian's sympathy. . . .

"In our loss it is the University's great consolation as it is Doctor Reinhard's contribution to Catholic education that his students, priests and brothers and nuns, lay men and lay women, will carry on his work, and in their dedicated lives their former teacher will have an ever widening influence."

REV. PLACIDUS REISCHMAN

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One New and One Previously Unreported Species of Nasal Mite (Acarina, Speleognathidae) from North American Birds

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The trombidiform family Speleognathidae at present contains approximately 31 species grouped in 4 genera. These genera are *Boydaia* Womersley, 1952 with neither dorsal eyes nor scutum; *Speleognathus* Womersley, 1936 with a pair of dorsal eyes but no scutum; *Speleognathopsis* Cooreman, 1954 with a dorsal scutum but no eyes; and *Astrida* Fain, 1955 with both dorsal eyes and scutum.

Two species are now known from North American birds. These are *Boydaia sturni* (Boyd, 1948) from the starling, *Sturnus vulgaris* Linn., 1758 and and *Speleognathus striatus* Crossley, 1952 from the domestic pigeon, *Columba livia* Gmelin, 1758. One species, *Boydaia longipilis* (Rosas Costa, 1955) has been described from a bird, *Guira guira* (Gmel.) in South America. The two species described in this paper will bring the speleognathids known from the Western Hemisphere to a total of five.

Fain (1956b) has recognized the existence of a homogeneous group of species in the genus *Boydaia* which seem to be morphologically identical with the type species. He designates these species as the "sturni" group and has erected a system of classification for these species on the basis of larval morphology, since there is marked genetic variability in those factors which govern larval morphology, particularly trasal configuration. Although the writer is of the opinion that the genus *Boydaia* should be restricted to the "sturni" group, Fain's interpretation will be retained for the present.

Sexual dimorphism in the speleognathids is extremely slight and no comprehensive rule for distinguishing sexes has been found. In certain species the relative length of the tarsal setae appears to be significant (Fain, 1956b) but such differences are subtle at best. Gravid females can be recognized by the presence of an egg in the opisthosoma.

Boydaia colini, n. sp.

FEMALE: (Figs. 1, 7, 8) Milky white to yellowish in color, occasionally with a median, longitudinal white streak caused by stored excretory materials in the gut; oval in shape with the greatest width in the propodosomal region; length, excluding gnathosoma, approximately 0.49 mm; width, at humeral region, approximately 0.33 mm.

GNATHOSOMA. Width at palpal bases approximately 0.08 mm; chelicerae blades minute; length of chelicerae approximately 0.06 mm dorsally; cheliceral bases bearing two pairs of small barbelled setae ventrally. With a pair of well developed, three-segmented palpi; palpal segments somewhat globular in shape, the middle segment the largest. Setal types are shown in Fig. 13. Palpal tarsus bearing 4 setae; ventrally with one expanded, type E seta, and one nude, lanceolate, type S, apically with one setated E seta and dorsally with one setated E seta, other palpal segments without setae; base of gnathosoma with sub-cuticular reticulations ventrally.

DORSUM. Eyes and scutum lacking, although remnants suggestive of eyes occasionally seen. Anteriorly with a pair of thin, barbelled, type W

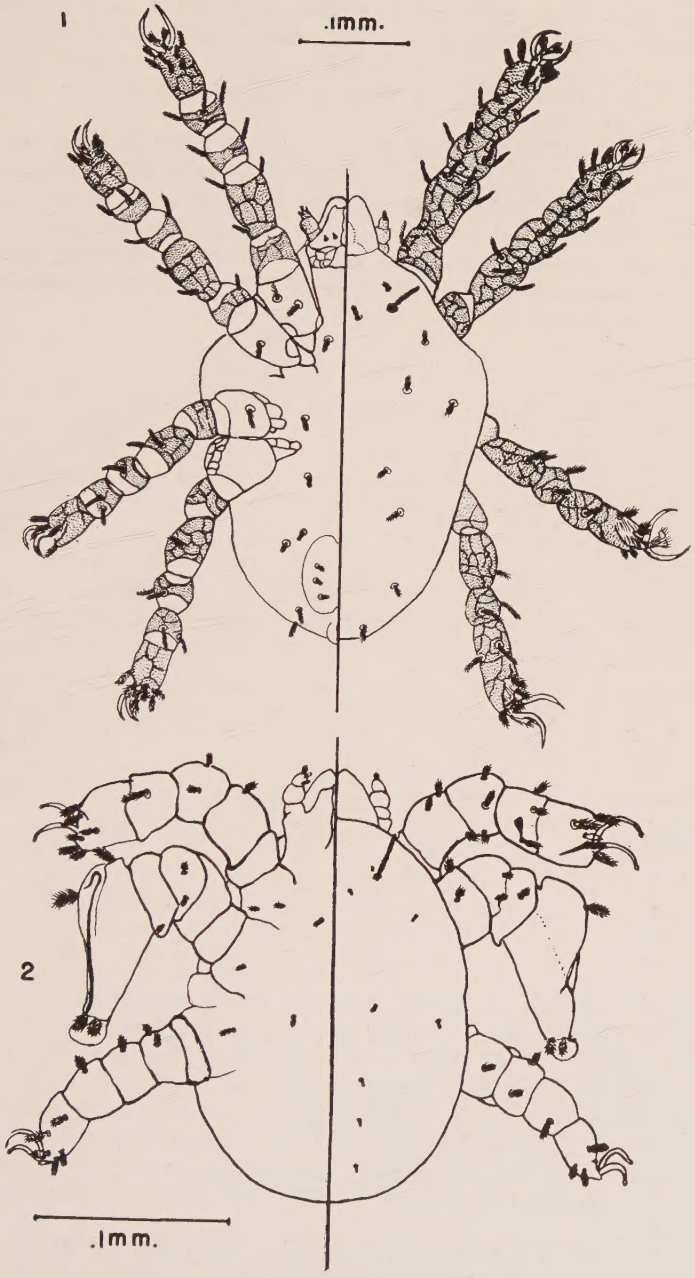

Figure 1. *Boydaia colini*, adult. Ventral and dorsal aspects.
Figure 2. *Boydaia colini*, larva . Ventral and dorsal aspects.

sensillae set in pseudostigmata. Anterior to the sensillae is a tiny pair of type P presensillar setae. The remaining dorsal setae are type P barbelled and are arranged in a 4 - 4 - 2 - 2 - 2 - 2 formula.

VENTER. With three pairs of type P sternal setae, two pairs of type P pre-genital setae, 3 pairs of type D genital setae and 2 pairs of type P post-genital setae; genital slit of variable length, ranging from 0.07 to 0.15 mm; distance between the coxae I from 0.04 to 0.05 mm; distance between coxae IV from 0.12 to 0.20 mm; distance between coxa II and coxa III ranging from 0.04 to 0.05 mm.

LEGS. Well developed, with marked sub-cuticular reticulations and surface punctations, marked striations lacking. Leg setae all of barbelled P and Y type, arranged as indicated in Table I. Each block in the table is constructed with the total setae number per segment at the top. Under this, from left to right, appear the dorsal and ventral setation numbers together with letters designating the type of setae. For an explanation of this system see Figure 13.

TABLE I.—Leg Setation of Mature *B. colini*

Leg	Coxa	Tro.	Fem.	Genu.	Tib.	Tars.
	T D V	T D V	T D V	T D V	T D V	T D V
I	2 2P	1 1Y	6 5Y 1Y	4 2Y 2Y	4 3Y 1Y	13 4H 4C 2C 1T 2H
II	1 1Y	1 1Y	4 3Y 1Y	4 2Y 2Y	3 2Y 1Y	9 1B 3C 3C 1T 1H
III	1 1Y	0	3 1Y 2Y	3 1Y 2Y	3 1Y 2Y	7 3C 4C
IV	0	0	3 2Y 1Y	3 1Y 2Y	3 1Y 2Y	7 3C 4C

The adult characters of *B. colini* agree so closely with those of the adult of *B. sturni* that this species should be placed in the "sturni" group.

LARVA: (Figs. 2, 5, 6) Color as in adult; shape roundly oval; size 0.285 mm long by 0.165 mm wide excluding gnathosoma which is 0.07 mm wide at base; gnathosoma with a pair of well developed, punctate, 3 segmented palpi; palpal tarsus with 4 setae, dorsally with a short setated type E seta, apically with a longer setated seta and ventrally with one setated and one nude sensory type S seta; cheliceral bases bear ventrally two pairs of short, barbelled, type N setae.

DORSUM. With a pair of slightly expanded barbelled sensillae preceded by a pair of short presensillar type M setae; dorsal setae type Y, short and barbelled, arranged in a 4 - 4 - 2 - 2 - 2 formula.

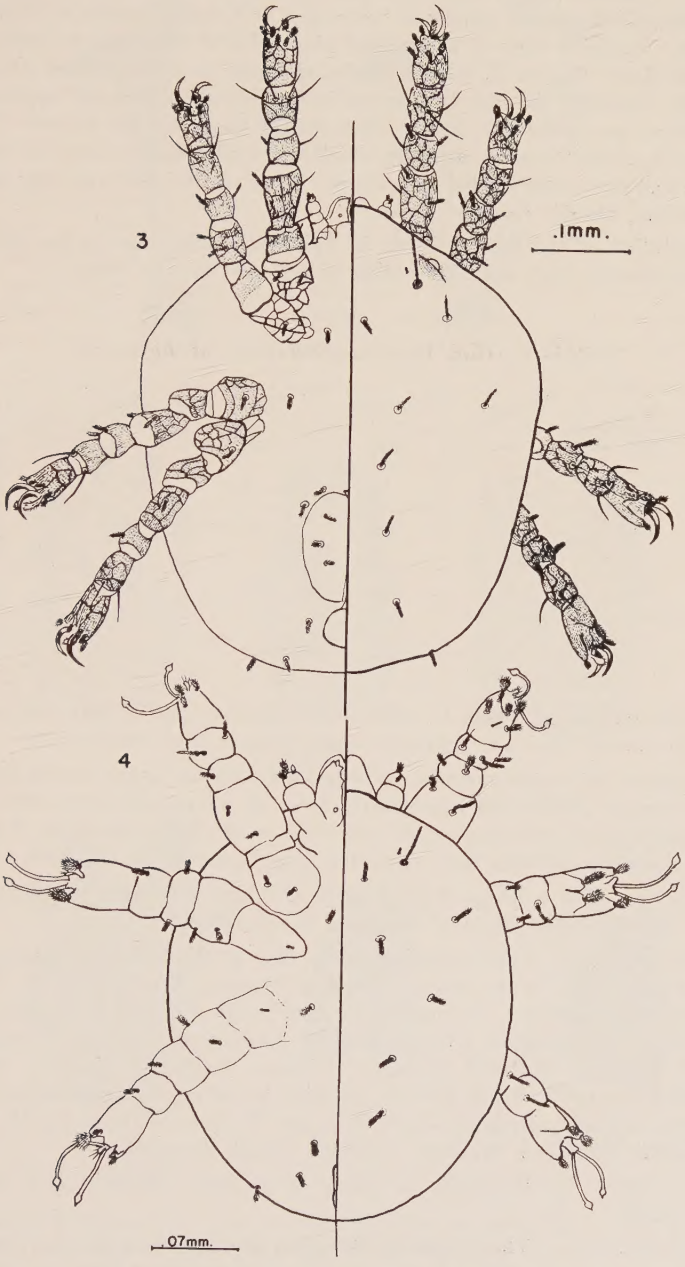

Figure 3. *Speleognathus womersleyi*, adult. Ventral and dorsal aspects.
Figure 4. *Speleognathus womersleyi*, larva. Ventral and dorsal aspects.

VENTER. Two pairs of sternal setae are found on the ventral surface.

LEGS. Tarsus of leg II expanded and produced (Figs. 5 and 6). Tarsi II bear 6 expanded setated setae and measure 0.087 mm in length by 0.038 mm in width. Exterior edge of these tarsi recessed and book-like to receive the retracted claw. Tarsus II with a single, elongate claw measuring 0.077 mm in length. Apically the claw is recurved into a "shepherd's crook" appearance. In mounted specimens the claw is often folded back into the tarsus. Tarsus II with a pad-like structure apically which bears internally 3 digit-like projections as well as a small setated empodium. Tarsi of the other two legs normal, with normal, bluntly rounded claws.

The setation of the legs is shown in Table II, which, due to the condition of the specimens, does not differentiate dorsal and ventral setae.

TABLE II.—Leg Setation of *Boydaia colini* Larvae

Leg	Cox.	Tro.	Fem.	Gen.	Tib.	Tars.
I	2X	0	5B	4B	4B	7C 3H 1T
II	1X	0	4B	4B	1B 1C	4A 2B
III	1X	0	4B	4C	2C	1B 1H 3C

The letter symbols in Table II indicate the relative type of seta but not size, since the larval setae are generally much smaller than adult setae.

DIAGNOSIS. *B. colini* may be distinguished from all other known members of the "sturni" group and particularly from *B. pycnonoti* Fain, 1956 by the size, configuration and setation of tarsus II of the larva which, in *B. pycnonoti* is not provided with four expanded apical setae as in *B. colini.*

HOLOTYPE. The holotype larva USNM #2452 is deposited in the collection of the United States National Museum, Washington, D. C.

TYPE MATERIAL: Type material will be filed at the following museums and institutions: The United States National Museum, Washington, D. C.; The Institute of Acarology, University of Maryland, College Park, Maryland; The Texas Technological College Zoology Collection, Lubbock, Texas; The British Museum (Natural History), London, England; Museum National d'Histoire Naturelle, Paris, France; Institut Royal des Sciences Naturelles de Belgique, Bruxelles, Belgium; Natal Museum, Pietermaritzburg, South Africa; and, South Australian Museum, Adelaide, South Australia.

TYPE HOST: The type host is *Colinus virginianus* (Linn., 1758), the Bobwhite Quail.

TYPE LOCALITY: The Patuxent Research Refuge, Laurel, Maryland.

REMARKS: *B. colini* has also been taken from the bobwhite quail in Lubbock County, Texas. Adult speleognathids in the "sturni" group have been found on the Scaled Quail, *Callipepla squamata pallida* Brewster, 1881, in Lubbock County, Texas.

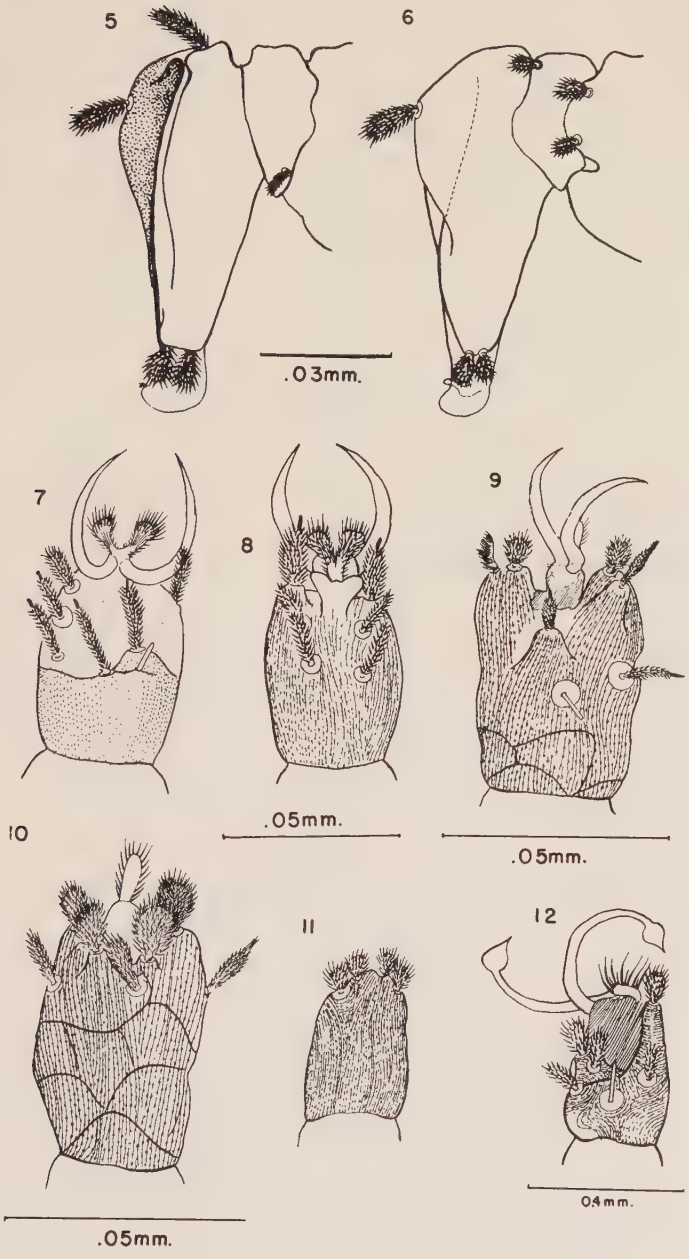

Figure 5. *Boydaia colini*, larva. Ventral view of tarsus II.
Figure 6. *Boydaia colini*, larva. Dorsal view of tarsus II.
Figure 7. *Boydaia colini, adult.* Dorsal view of tarsus I.
Figure 8. *Boydaia colini*, adult. Ventral view of tarsus I.
Figure 9. *Speleognathus womersleyi*, adult. Dorsal view of tarsus I.
Figure 10. *Speleognathus womersleyi*, adult. Ventral view of tarsus I.
Figure 11. *Speleognathus womersleyi*, larva. Ventral view of tarsus I.
Figure 12. *Speleognathus womersleyi*, larva. Dorsal view of tarsus I.

Speleognathus womersleyi Fain, 1955.

Number of speleognathids indistinguishable from *S. womersleyi* Fain, 1955 (1956b) have been taken from the Lesser Scaup Duck, *Aythya affinis* (Eyton, 1838) in Minnesota and Texas. Adult stages have also been found in the Pintail, *Anas acuta* (Vieillot, 1816) and the Gadwall, *Anas strepera* (Linn. 1758) both in Texas. In the present paper the female of this species is refigured and the larval stage is figured and described for the first time.

Female: (Figs. 3, 9, 10) Description agrees with that of Fain, 1955 with the following exceptions. The cuticle, especially that of the legs and gnathosoma, is finely tuberculo-striated. The pair of setae on the ventral cheliceral bases is extremely minute and may be represented solely by tiny setal plates. The dorsal setal formula is 4 - 4 - 2 - 2 - 2. Setal types are shown in Figure 13. Dorsal setae are type J, sternal setae type K and E, genital setae type D, tarsal setae A, B, G. F. T, other leg setae type K and U.

Larva: (Figs. 4, 11, 12) Whitish, measuring 0.34 mm in width by 0.36 mm in length excluding gnathosoma. In cleared material stored excretory crystals may form a longitudinal, median opaque color band. Slightly sclerotized cuticle finely striated and tuberculated, with vague subcuticular chitinous banding on the podosoma and to a lesser degree on the legs.

The figured larva, so indicated, is deposited in the collection of the U. S. National Museum.

Gnathosoma. Width at palpal bases 0.08 mm; palpi well developed with 3 segments; chelicerae with minute, bi-dentate apical blades; palpal tarsus with a nude lanceolate type R, and a setated type X seta ventrally, one setated seta apically and one setated seta dorsally; cheliceral bases with a pair of setal pits ventrally.

Body: Venter with 2 pairs of type M, podosomal and 3 pairs of M opisthosomal setae; dorsum with a pair of finely setated sensillae and type L dorsal setae in a 4 - 4 - 2 - 2 formula.

Legs. Legs approximately equal in development, all tarsi with curving claws which expand apically to an arrow-shaped point, and a single lobed, setated empodium. Leg setation is shown in Table III.

TABLE III.—Leg Setation of *S. womersleyi larva*

Leg	Cox.		Tro.		Fem.		Gen.		Tib.		Tars.	
	T		T		T		T		T		T	
	D	V	D	V	D	V	D	V	D	V	D	V
I	2	2L	0		4 1K 1L	2L	4 2K	2K	4 2L	2L	10 2A 3B 1T	4A
II	1	1L	0		3 2L	1L	4 2K	2L	2 1J	1L	6 4A	2A
III	1	1L	0		3 1J	2L	3 1J	2L	2 1J	1L	5 2A 1B	2A

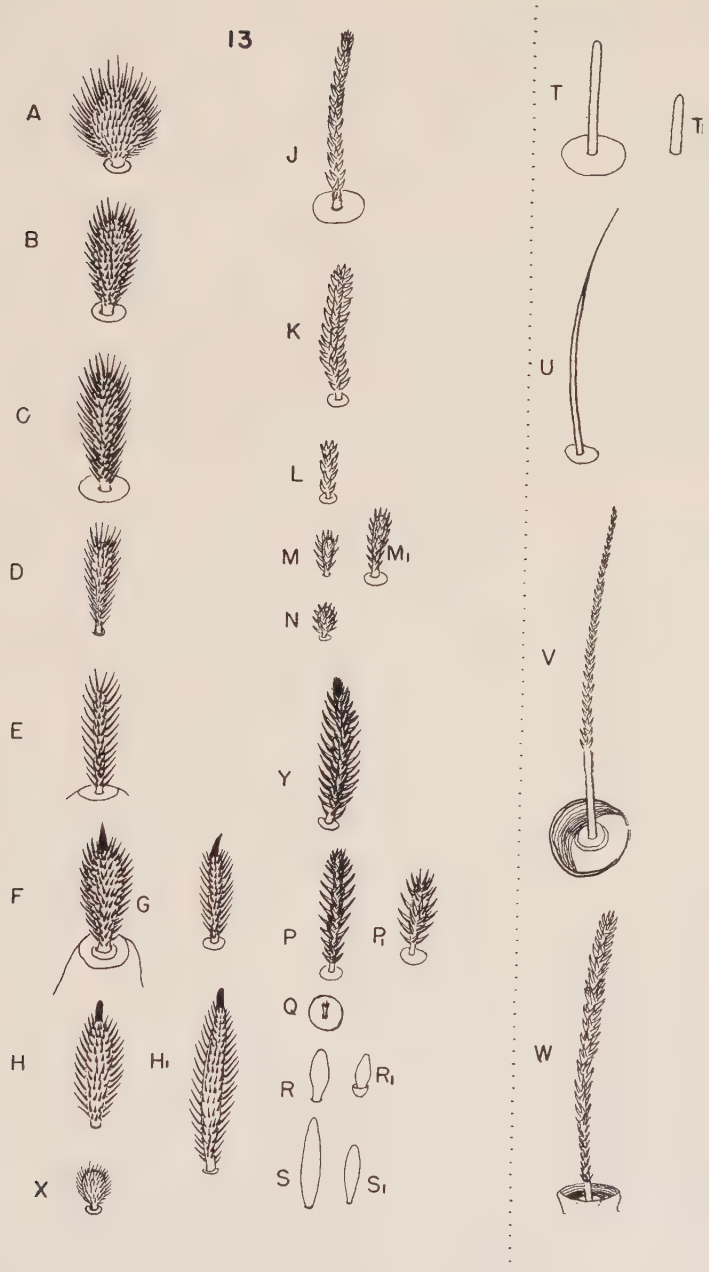

Figure 13. Setal types in *Boydaia colini* (A-E, H, M, N, P, T, W, X, Y) and *Speleognathus womersleyi* (A-G, J-M, R, T, U, V, X).

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Observations on Inhibited Development of Cattle Nematodes*

H. H. VEGORS**

The retarded development of nematode parasites in resistant hosts has been observed by many workers. By way of illustration, Sommerville (1954) has shown that larvae of *Ostertagia circumcincta* that have undergone the third ecdysis may remain in the abomasal mucosa of sheep as long as three months without further development. Michel (1955) also found that calves reexposed to *Dictyocaulus viviparus* after recovery from a previous lungworm infection did not acquire a patent reinfection as a result of the second exposure, and that considerable numbers of immature worms were still present in their lungs several months after this reexposure to infective larvae. The significance of this phenomenon in relation to the control of parasitic disease in ruminants has been the subject of considerable recent discussion. Taylor and Michel (1953) have suggested that dormancy may provide a means of survival until a depression in the host's state of resistance allows the parasites to proceed through normal growth to maturity.

During the course of previous work at the Georgia Agricultural Experiment Station (Vegors *et al.*, 1955), it was observed that larval forms accounted for 30-60 per cent of the total worms recovered at necropsy from Hereford yearlings slaughtered immediately after they were taken off pasture in late spring. The majority of the adult worms recovered from these animals were *Ostertagia ostertagi* and *Trichostrongylus axei*. Since the number of infective larvae recovered from the forage during the grazing period

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The cooperation of the Georgia Experiment Station in furnishing the animals, feed, and facilities for these experiments is much appreciated. Also, the assistance of Dr. H. Ciordia, Parasitologist, U.S.D.A., in the identification and enumeration of the nematodes recovered during the second year's experiment is gratefully acknowledged.

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in May and June was usually at a low ebb as compared with the relatively large number found during March and April, the question arose as to whether the larvae found at post-mortem were recently acquired or were ingested at a much earlier time and retained for a prolonged period in an arrested state of development. Accordingly, experiments were carried out in order to investigate further this facet of the host-parasite relationship. Some of the results of this study, here reported in full, have been published previously in abstract form (Vegors, 1957).

METHODS

In each of two successive years, four grade Hereford yearlings were taken from pasture in late spring, placed in a barn, and fed hay or hay and grain for 28 days. At the end of the 28-day period, they were slaughtered and examined for gastrointestinal helminths. These animals were selected from larger groups which had been grazing an average of 92 days on crimson clover, ryegrass, or oat pastures. At the time they were transferred to the barn, two or three cattle, comparable in age and previous exposure to parasites, were taken from each pasture and necropsied. Hereinafter, the animals kept in the barn for 28 days after grazing will be referred to as the test group and those killed immediately at the end of the pasture phase of the experiment will be identified as the control group.

The two barn stalls in which the animals in the test group were placed the first year had a hard dirt floor, which was cleaned twice daily; sawdust was replaced on the floor after each cleaning. The second year two concrete-floored stalls were available; they were cleaned daily and no bedding was used. The hay and grain (oats the first year and cracked grain sorghum the second year) were fed from racks and troughs elevated from the floor in such a way that a minimum of wastage occurred.

The post-mortem technique of Porter (1942) was used for the recovery of the worm parasites from the animals and for estimating the numbers of the different species present. The findings in the controls served as the index of the extent and type of infection at the end of the grazing period. Adult and larval worms were separately enumerated. Larval forms recovered from both the test and control groups of animals were identified as to genus in the second experiment, but were not so identified in the first experiment.

RESULTS

At the end of the 28-day post-grazing period there were still numerous larvae in the abomasa and a smaller number in the small intestines of the test cattle (table 1). On the average, larvae constituted 12 per cent of the total number of worms recovered from them, whereas larvae constituted 34 per cent of the worms from the controls. Conversely, 88 per cent of the worms recovered from the test cattle and 66 per cent from the controls were adults. The average number of adult worms recovered from the test cattle, kept in the barn for 28 days, was about double the number from the controls, whereas the number of larvae recovered from the former was approximately one-half the number from the latter animals.

The greatest difference in adult worm populations was in the abomasa, especially in numbers of *T. axei*. Slightly over three times as many *T. axei* were recovered from the test animals as were found at necropsy in the controls. The average numbers of *O. ostertagi* and *Haemonchus placei* (see foot-

note, table 1) recovered from the test and control animals followed the same general trend as for *T. axei*. The total numbers of adult intestinal worms recovered from the two groups did not differ significantly. The only definite differences were the small number of *Cooperia oncophora* found in those animals necropsied at the end of 28 days in the barn as compared with the number in the control group and the presence of *Trichostrongylus colubriformis* in the test group as compared with the absence of the latter species in the control group. *C. punctata* was found in both groups in approximately equal numbers, while insignificant numbers of *Oesophagostomum radiatum* were recovered.

The average number of stomach worm larvae found in the test cattle was slightly more than half the number found in the controls. The larvae of the intestinal worms were one-sixth as numerous in the former as in the latter animals.

As previously noted, the larval forms recovered in the second experiment were identified generically. All the larvae found in the intestines of both groups of animals were fourth-stage *Cooperia* spp. Fourth-stage larvae of *O. ostertagi* were recovered from the abomasa of the control and test animals, whereas fourth-stage larvae of *T. axei* were found only in the controls (table 2).

DISCUSSION

The failure to recover larvae of *T. axei* and the recovery of large numbers of adults of this species from animals kept in the barn for 28 days in the

TABLE 1.

Nematodes recovered from test and control cattle in Experiments 1 and 2.

Nematodes	Average No. of nematodes from 11 cattle—pasture only	Average No. of nematodes from 8 cattle—pasture plus 28 days in barn
	Abomasum	
Adults:		
*H. placei**	100	500
O. ostertagi	5,300	9,600
T. axei	3,800	11,600
Totals for 3 species	9,200	21,700
Larvae	6,100	3,200
	Intestine	
Adults:		
C. punctata	1,900	2,300
C. oncophora	1,500	100
T. colubriformis	0	1,500
O. radiatum	100	0
Totals for 4 species	3,500	3,900
Larvae	600	100
Totals for 7 species and % of total worm load—		
Adults	12,700 (66%)	25,600 (88%)
Larvae	6,700 (34%)	3,300 (12%)

*Probably specimens meeting the morphological criteria laid down by Roberts *et al.* (1954) for *H. contortus* as well as specimens of *H. placei* of these authors were present; the worms were not studied in detail.

TABLE 2.—Adult and larval forms of the two most numerous species of nematodes recovered from abomasa of test and control cattle in the second experiment.

Species	Nematodes from 6 cattle—pasture only		Nematodes from 4 cattle—pasture plus 28 days in barn	
	Average number recovered	Per cent of total No. of worms	Average number recovered	Per cent of total No. of worms
O. ostertagi:				
Adults	6,900	62	8,800	72
Larvae	4,300	38	3,500	28
Total	11,200	100	12,300	100
T. axei:				
Adults	4,000	77	8,800	100
Larvae	1,200	23	0	0
Total	5,200	100	8,800	100

second experiment agree fairly well with what might be expected to happen after four weeks without further exposure to infection. However, almost 80 per cent of the larvae of *O. ostertagi* apparently did not develop beyond the fourth stage during this period. Furthermore, some larvae of *Cooperia* spp. were still present at the end of the barn test. These facts indicated that larvae of these two species were inhibited in their development, since they were apparently unable to develop into adults within the time usually required for passage from the infective stage to sexual maturity. Among other factors, this may possibly have been due to an acquired immunity developed by the animals.

The finding of many *O. ostertagi* larvae after a period of almost a month without apparent further exposure to infection indicates that the problem of control may be complicated by the phenomenon of arrested development. Phenothiazine is the drug of choice for anthelmintic treatment of cattle, but it is known to be ineffective against larvae. A common recommendation is that cattle be treated with this drug at the beginning of a dry-lot feeding period, and treatment is occasionally advised again after two or three weeks, when, according to the presumption, the larvae would have matured. In view of the arrested development of the parasite here reported, further investigations are needed concerning the therapeutic treatment of ostertagiasis of cattle, especially the value of repetitive doses and their spacing; there is no evidence that *O. ostertagi* larvae leave the mucosa when the adults are removed by anthelminthic treatment as Gibson (1953) reported for *Trichonema* spp. of horses.

Although more adult stomach worms and fewer stomach worm larvae were recovered from the test than from the control animals and the test animals yielded the greater number of adult and larval stomach worms combined (table 1), these facts are not considered to invalidate the interpretation that many of the larvae acquired by the cattle while grazing were retained for at least 28 days in a state of arrested development.

The possibility that some few infective larvae may have been available to the test animals while in the barn must be conceded. However, every effort possible under the existing circumstances was made to prevent reinfection, and the animals were never observed eating off the barn floor. Moreover,

some evidence that reinfection in actuality very probably did not occur in the barn is available. For instance, in the second experiment the number of *T. axei* adults recovered from the test animals exceeded the sum of adults and larvae of this species found in the controls (table 2). If this were due to reinfection in the barn, very likely at least some *T. axei* larvae would have been recovered from the former group. Actually none were recovered from any of its four members. Moreover, *T. colubriformis* was recovered only from the test animals of the first experiment. If it had been barn-acquired, very probably some immature or larval forms of this species also would have been found. Actually, no larvae whatsoever were recovered from the small intestines of the animals infected with adults of this species.

The writer concedes that the use of experimentally infected animals provides the best method for conducting the type of test reported herein. Still, it could yield data that would not obviate the need for interpretative judgment, since individual animal variation is always an important and uncontrollable factor. Lucker (1953) has shown that young lambs were not uniform in susceptibility to initial infections with *H. contortus*. Although other authors generally have not stressed the point, much published data could be cited to show that there is marked variation in the number of worms recovered after presumably uniform groups of animals have been given equal numbers of infective larvae of one or more species.

Summary

The results of limited experiments indicated that a high proportion of parasitic larvae present in cattle at the end of a period of grazing persisted as larval forms for an additional period of 28 days after the animals were transferred to a barn. The great majority of the fourth-stage larvae recovered at necropsy from eight animals after barn confinement for this period were *Ostertagia ostertagi;* a few *Cooperia* spp. larvae also were present. *Trichostrongylus axei* apparently did not remain in an arrested stage of development.

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Notes on *Azygia pristipomai* Tubangui, the Genus *Azygia* and Related Genera (Digenea: Azygiidae)

CARMEN C. VELASQUEZ

Examination of 182 *Therapon argenteus* (Cuvier) (silver perch), a fresh water fish commonly called ayungin (Tagalog), for helminth infection yielded 17 flukes from the opercular cavity, stomach and intestine of 6 hosts. The fish bought from Manila markets and vicinity had been taken from Laguna de Bay, Tanay, Rizal province, and Sta. Rosa, Laguna province, both localities being on Luzon island.

The specimens were fixed in Bouin's picro-formal under cover slip. Due to the muscular nature and contractility of the body, some of the specimens were contracted; nevertheless, they were included in the measurements. The worms were kept for 24 hrs. in the fixative and later stored in 70% glycerine alcohol. Part of the material was stained in aceto-carmine and the rest in Harris' hematoxylin of 4:1 dilution for each stain.

Azygia pristipomai TUBANGUI, 1928

Study of specimens shows that they are identical with *Azygia pristipomai* Tubangui, 1928. Unfortunately, Tubangui's type specimen was destroyed during the Japanese Occupation, World War II. Since Tubangui's report no additional record of this species has been presented, not because of its rarity but rather because of the paucity of workers in the field.

This species is here reported for the second time in a new host from the same lake but from a locality different from that of Tubangui's. Additional data on organs infected are also presented together with the variability of certain characters.

The general shape of the body, body measurements and relative proportions fall within the range of *Azygia pristipomai,* including the egg size (Table I).

It was noted that the extent of the vitellaria and the relative position of the genital organs were variable (Plate I, figs. 1-3). The presence of the oesophagus which Tubangui failed to see is shown in Fig. 4. A receptaculum seminis uterinum, not seen by Tubangui, was noted just above the ovary (Figs. 1 and 2). In one specimen (Fig. 3), the oötype was clearly discernible.

TOPOTYPES: U. S. Nat. Mus. Helm. Coll. No. 38305; and

Department of Zoology, University of the Philippines' Helm Coll. Nos. 480 (1) f_2; 500 (1) f.

DISCUSSION

Azygia Looss, 1899, a genus of digenetic trematode (Azygiidae), has been reported from Europe, North America, Japan, India, China and the Philippines. The genus seems to present a great deal of confusion. Manter (1926)

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This investigation was made while the author was a Guggenheim Fellow and University of the Philippines Fellow. Collections of the materials were made through a grant-in-aid of the Natural Science Research Center, University of the Philippines. The identification of the fish hosts were made by Mr. Augustin Umali, Ichthyologist, National Museum, Philippines.

I am very grateful to Dr. George R. LaRue, Animal Parasite Laboratory, Animal Disease and Parasite Research Division, Agricultural Research Center, Beltsville, Maryland, for the use of his laboratory and his very helpful comments and criticisms; to Mr. Allen McIntosh of the same institution who has so very kindly helped in various ways; to Dr. John S. Andrews, Head, Helminthological Investigations of the above-named institution, and to Dr. George W. Wharton, Head, Department of Zoology, University of Maryland, for their generosity in providing the needed laboratory facilities.

in his key to the American species of *Azygia* containing several doubtful European species was of the opinion that they might represent a single species, *A. lucii* (Muell. 1776). Belozerova-Sypliakova (1937) has shown the variability in the distribution of the vitellaria in *Azygia lucii*. Stunkard (1955) in his studies on the life cycle of *Azygia sebago* Ward compared the worms from the eel (*Anguilla rostrata*) with published descriptions and with specimens from the U. S. National Museum and stated "Ward's description may have included material of more than one species." He further stated that the three species, *A. acuminata, A. bulbosa* and *Hassallius hassalli,* described by Goldberger (1911) may be identical with *A. sebago*. However, Manter (1926) had synonymized *A. sebago* Ward with *A. longa* (Leidy) It is evident that a direct comparison of specimens referred to the various species of *Azygia* should be made in order to resolve this confusion.

While going over the literature, two species, *Eurostomum micropteri* MacCallum, 1921, and *Gomtiotrema attu* Gupta, 1953, were noted to present characteristics of *Azygia*. The description of *Eurostomum micropteri* was based on a single specimen taken from *Micropterus salmoides*. This species was placed by Yamaguti (1953) in the family Opisthorchiidae. Fortunately, I was able to study MacCallum's type specimen which is deposited in the U. S. National Museum collections (No. 36094). The general characteristics of the body and body measurements (Table I) show that it is congeneric with *Azygia*. The cirrus sac which MacCallum failed to see is definitely present

Figs. 1-3. Posterior portion of 3 specimens of *Azygia pristipomai* Tubangui showing the variation in the relative position of the genital organs and vitellaria.
Fig. 4. Anterior portion of a worm showing the oesophagus.
All figures drawn with the aid of a camera lucida.

TABLE I. Comparative measurements of *Azygia pristipomai* Tubangui and related genera in mm.

	Azygia pristipomai Tubangui 1928			*Azygia longa* (Leidy)**	*Eurostomum micropteri* MacCallum 1928	*Gomtiotrema attu* Gupta 1953
	Tubangui	Velasquez	Mean*			
Length	1.93-3.2	1.4-3.42	2.452	2.10-7.0(9)	4.00	5.7-12.4***
						11.96
Width	0.86-1.00	0.35-1.4	0.829	0.42-0.91(9)	0.80	1.42-2.2***
						2.1
Oral sucker diameter	0.34-0.45	0.25-0.595	0.381	0.31-0.63(7)	0.480	1.00
length		0.22-0.5	0.318	0.28-0.6(7)		0.89
Acetabulum diameter	0.31-0.38	0.2-0.52	0.321	0.25-0.46(9)	0.280	0.88
length		0.18-0.385	0.256	0.25-0.45(7)		0.74
Acetabulum to anterior end		0.425-1.32	0.777			1.9
Pharynx diameter	0.16-0.18	0.065-0.19	0.101	0.11-0.25(7)		0.26
length		0.05-0.15	0.096	0.14-0.28(7)		0.24
Genital pore to anterior end		0.41-1.0	0.679			0.58
Eggs	0.066-0.068 by 0.040-0.044	0.056-0.065 by 0.035-0.039		0.042 by 0.025(36)	0.040 by 0.024	0.048-0.06 by 0.030-0.032

*Mean of 15 specimens.

***Azygia longa* (Leidy) based on Linton's description. Parentheses indicate number of specimens measured.

***Range. Other measurements in this column are from the type specimen as given by Gupta.

and similar to that in other Azygiidae. Comparison of the type specimen of *Eurostomum micropteri* and specimens labeled *A. longa* (Leidy) by Linton in the U. S. National Museum Helminthol. Collection (Nos. 8302 and 8303) seems to indicate that the two species are rather similar in shape of body, in other proportions, and position of the genital organs. Leidy's type specimens were unstained and hence not available for comparison except for the relative size. Linton's (1940) description agrees with the characteristics of *Eurostomum micropteri*. See Table I for comparative measurements. In view of the above facts I conclude that *E. micropteri* is an objective synonym of *A. longa*. Skrjabin and Gushanskaia (1956) correctly placed *Eurostomum* in the family Azygiidae.

Gupta (1953) erected the genus *Gomtiotrema* for the species *attu*, placed this genus in the sub-family Gomtioteminae, family Opisthorchiidae. Unfortunately, no specimens are available to me for critical study. The presence or absence of the cirrus sac needs rechecking. Gupta did not show one and stated that it was absent. The nature of the excretory bladder as described is characteristic of the family Azygiidae not of the Opisthorchiidae. *Gomtiotrema* Gupta is a homonym of *Gomtiotrema* Sinha, 1934, erected for a blood fluke belonging to the family Spirorchiidae. Mehra (1939) pointed out that *Gomtiotrema* Sinha, 1934, was a synonym of *Plasmiorchis* Mehra, 1934, which had priority. Byrd (1939) in turn reduced *Plasmiorchis* Mehra (1934) to synonymy with *Spirorchis* MacCallum, 1918. Comparison of the description of *Gomtiotrema attu* Gupta with specimens of *Azygia* forces me to conclude that *Gomtiotrema* is congeric with *Azygia*. See Table I for comparative measurements. Consequently, the genus *Gomtiotrema* falls as a synonym of *Azygia*.

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A New Species of Sting Nematode

GEORGE J. RAU*

The genus *Belonolaimus* was established by Steiner in 1949 with *B. gracilis* Steiner, 1949 as the only species, the specimens described having been collected from soil around the roots of slash pine near Ocala, Florida. During the past several years collections made in the vicinity of Ocala and in other parts of Florida have not contained specimens corresponding to the description of *B. gracilis,* but have contained a nematode of somewhat similar appearance, described herein as *Belonolaimus longicaudatus,* n. sp.

THE GENUS *Belonolaimus* Steiner, 1949

The genus *Belonolaimus* was placed in the *Tylenchidae* by Steiner and in the subfamily *Dolichodorinae* by Chitwood and Chitwood, 1950. Known species have slender, cylindrical bodies with lengths a little more than 2 mm. for the females and a little less than 2 mm. for the males. The distinctly rounded lip region is divided by lateral, dorsal and ventral grooves into four distinct lobes, each of which bears 6 or more striations. Viewed *en face,* six distinct lips can be distinguished, with amphidial openings near the outer edges of the lateral ones. The body is strongly annulated, the annules extending around the terminus of the female tail. The lateral fields are marked in both sexes by a single line. The stylets of both males and females are long and slim with distinct knobs. The oesophageal glands form a lobe overlapping the anterior end of the intestine. There are two outstretched ovaries with distinct spermathecae. The testis also is outstretched. The spicules are curved; there is a well-developed gubernaculum and the bursa envelops the tail end.

Belonolaimus longicaudatus, n. sp.

FEMALE DIMENSIONS (average, minimum and maximum of 22 specimens): length 2.2 mm. (2.0-2.6 mm.); width 34 microns (30-40 microns); a—65.4 (55.7-74.9); b—8.4 (7.3-9.9); c—16.1 (14.5-18.0); V—50% (46-54%); lip region 9.4 microns (8.4-10.4 microns) wide by 17.8 microns (16.8-18.8 microns) long; stylet 118 microns (100-133 microns) long; hemizonid 202 microns (173-217 microns) from anterior end; excretory pore 215 microns (184-233 microns) from anterior end; phasmid 126 microns (104-144 microns) from terminus.

MALE DIMENSIONS (average, minimum and maximum of 22 specimens): Length 1.8 mm. (1.6-2.1 mm.); width 29 microns (23-33 microns); a—63.7 (54.0-76.4); b—7.1 (6.3-8.1); c—14.6 (12.9-16.9); lip region 8.7 microns (8.4-9.8 microns) wide by 14.2 microns (14.0-15.4 microns) long; stylet 113 microns (107-123 microns) long; hemizonid 185 microns (167-210 microns) from anterior end; excretory pore 192 microns (177-220 microns) from anterior end; phasmid 98 microns (83-131 microns) from terminus; spicules 43.7 microns (43.4-46.2 microns) measured on chord of arc; gubernaculum 15.5 microns (15.4-16.8 microns) long with posterior flexure 5.7 microns (4.6-7.0 microns) long.

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*Nematology Section, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Sanford, Florida.

These were cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and the Central Florida Experiment Station.

FEMALE (HOLOTYPE): Length 2.5 mm.; width, 33 microns; a—70.6; b—9.5; c—17.2; V—48%; lip region 8.4 by 16.8 microns; stylet 117 microns long, hemizonid 203 microns from anterior end; excretory pore 213 microns from anterior end; body annules about 2.4 microns wide on anterior end and about 1.9 microns wide on tail, rounded stylet knobs 6.3 microns wide by 3.1 microns long; outlet or dorsal oesophageal gland 4.3 microns from base of stylet; tail 144 microns long; phasmid very small, apparently 126 microns from tail tip; eggs in uteri 27 by 140 microns; median oesophageal bulb 21 microns wide by 26 microns long; anterior ovary is 22% and the posterior ovary is also 22% of the body length. The lip region is set off from the body by a distinct constriction and each of its 4 lobes has 6 distinct striae. The stylet is thin and apparently flexible. When it is retracted, the oesophageal tube lies in convoluted folds.

MALE (ALLOTYPE): Length 1.8 mm.; width 27 microns; a—67.6; b—?; c—12.9; lip region, 9.8 microns wide by 14.0 microns long; stylet 110 microns long with knobs 2.5 × 4.2 microns; hemizonid 170 microns from anterior end; excretory pore 180 microns from anterior end; phasmid 103 microns from terminus; spicules 43.4 microns measured on chord of arc; gubernaculum 16.8 microns long with posterior flexure 7 microns long; tail 140 microns. The bursa extends from in front of the spicules around the tail tip.

HOLOTYPE: Female collected May 21, 1957 by W. Lautz. Deposited in the collection of the Nematology Section, Beltsville, Maryland.

ALLOTYPE: Male from same collection as holotype.

PARATYPES: Data same as for holotype. Deposited in various collections.

TYPE HABITAT: Soil around roots of *Zea mays* L.

TYPE LOCALITY: Young Farm, east of Central Florida Experiment Station on north side of State Road 415, Sanford, Florida.

DIAGNOSIS: *Belonolaimus longicaudatus* is distinguished from *B. gracilis* by the longer tail of the female (c—16.1 as compared with 19.2); by the shorter stylet of the female (average 118 microns, with a maximum of about 133 microns compared with 157 microns); by the location of the female phasmids 126 microns (minimum about 104 microns) as compared with about 77 microns (as measured on Steiner's drawing of *B. gracilis*). For ready identification of the two species, it might be noted that the tail length of *B. gracilis* is about 3 times the anal body diameter, while the tail length of *B. longicaudatus* is nearly 5 times the anal body diameter.

The author has found *B. longicaudatus* around the roots of the following plants at various specified places in Florida:

Apium graveolens L., Sanford, Florida.

Arachis hypogaea L., Sanford, Florida.

Brassica oleracea var. *capitata* L., Sanford and Ovieda, Florida.

Capsicum frutescens L., Lake Monroe and Sanford, Florida.

Citrus sp., Sanford, Florida.

Cornus florida L., Juniper Springs, Florida.

Cucumis melo L., Sanford, Florida.

Cucurbita maxima Duchesne, Sanford, Florida.

Cynodon dactylon (L.) Pers., Marineland, New Smyrna Beach, Sanford, Titusville Beach, Vero Beach, and West Palm Beach, Florida.

Cyperus rotundus L., Sanford, Florida.

Eremochloa ophiuroides (Munro) Hack., De Bary, Florida.

Fragaria hybrid, Samsula, Florida.

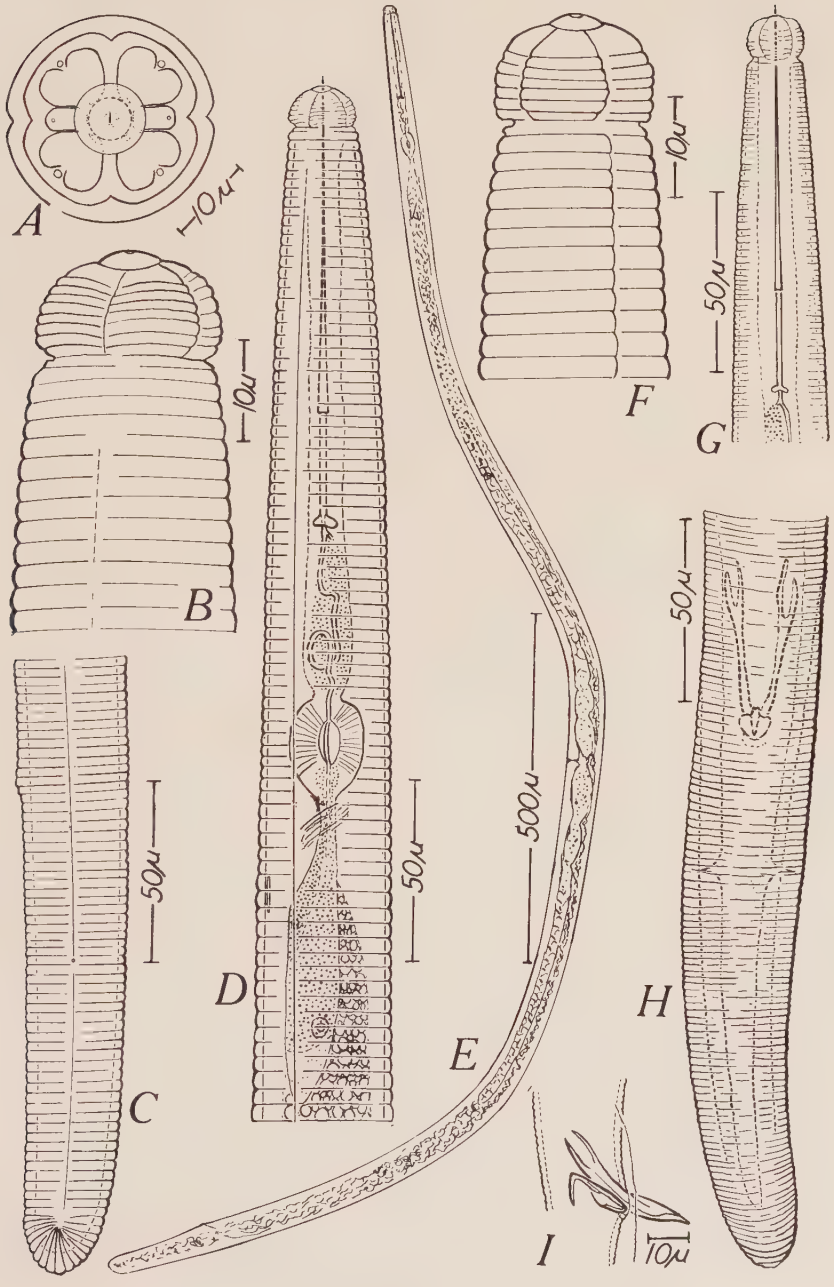

Figure 1. *Belonolaimus longicaudatus, n. sp.* A—En face view of female. B—Female lip region and beginning of lateral line. C—Female tail. D—Anterior portion of female body. Lateral line to left of center. E—Female. F—Male lip region and beginning of lateral line. G—Anterior portion of male body. H—Male tail. I—Spicule and gubernaculum.

Glycine max (L.) Merr., Sanford, Florida.
Gossypium hirsutum L., Sanford, Florida.
Ipomoea pes-caprae (L.) Sweet, New Smyrna Beach, Florida.
Lactuca sativa L., Samsula and Sanford, Florida.
Lolium multiflorum Lam., Lake Mary, Florida.
Lycopersicon esculentum Mill., Sanford, Florida.
Magnolia virginiana L., Sanford, Florida.
Phaseolus vulgaris L., Sanford, Florida.
Pisum sativum L., Sanford, Florida.
Raphanus sativus L., DeBary, Florida.
Sambucus canadensis L., near the "Big Tree," Sanford, Florida.
Solanum melongena L., Lake Monroe, Florida.
Solanum tuberosum L., Sanford, Florida.
Stenotaphrum secundatum (Walt.) Kuntze, Deland and Sanford, Florida.
Uniola paniculata L., New Smyrna Beach and Titusville Beach, Florida.
Vigna sinensis (Torner) Savi, Sanford, Florida.
Zea mays L., Sanford, Florida.
Zoysia matrella (L.) Merr., Miami, Florida.

The fact that *B. longicaudatus* is easily found in Florida as compared with *B. gracilis* suggests that the former is the common sting nematode of the southeastern United States, and not the latter as has been assumed (viz. first seven and last references). Graham and Holdeman (1953) reported a maximum distance of 133 microns and a minimum distance of 114 microns from the anterior end to the base of the stylet of sting nematodes from cotton in South Carolina, which is in the range of *B. longicaudatus*. However, the possibility of other undescribed species being involved cannot be disregarded.

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A Preliminary Study of Lateral Migration by Infective Larvae of Some Cattle Nematodes on Experimentally Contaminated Forage Plots*

I. BARRY TARSHIS**

Insofar as the author is aware very little information is available on the lateral migration of the larvae of nematode parasites of cattle and other ruminants. Dinaburg (1944) reported that horizontal migration of infective larvae of *Haemonchus contortus* on outdoor grass plots was comparatively slight, and Furman (1944a) found that infective larvae of *Ostertagia circumcinta* migrated laterally in soil not more than 2 inches from the site of inoculation.

As a part of a study of the behavior of infective larvae of various cattle nematodes on different forage crops commonly used for pastures in Georgia, a series of experiments was conducted to determine the extent of lateral migration on three such forages by larvae of some of the common trichostrongylids of southern cattle. The purpose of these experiments was to determine what size forage plots would be necessary for long-range ecological observations.

MATERIALS AND METHODS

The experimental work was carried out at Experiment, Georgia, in a greenhouse and outdoors on forage plots initially free of infective larvae of animal parasites.

The larvae used in these studies were obtained from cultures of feces from naturally and experimentally infected calves. In the preparation of the fecal cultures sterile sphagnum moss (Cauthen, 1940) was added to mixtures of feces and tap water. The fecal cultures were kept in slop pails at room temperature for 8 to 11 days, though the greatest numbers of third-stage larvae were always obtained prior to the 9th day. As fairly moist cultures gave the greatest yields of larvae, the cultures were sprayed every other day with a bulb-type hand sprayer.

The larvae were obtained from the cultures by the use of the Baermann apparatus. A graduated centrifuge tube was fitted over the rubber tube of the apparatus for continuous collection of the larvae. This centrifuge tube was removed from the apparatus just before the larvae were counted, and all fluid above the 10-ml. mark was drawn off and discarded; the number of larvae in the bottom 10 ml. was then determined. This same procedure was followed when forage samples were baermannized for the recovery of larvae.

During the baermannization of both forage samples and fecal cultures, the funnel was filled with warm water (approximately 104°F.) to within 2 to 3 inches of the rim. A single layer of sterile cheesecloth was placed on the surface of the water and extended over the edges of the funnel so that the entire forage sample or fecal culture was encased in cheesecloth when it sank down into the funnel.

Turfs of second year fescue (*Festuca arundinacea* Schred.), crimson clover (*Trifolium incarnatum* L.) on Bermuda sod (*Cynodon dactylon* (L.)), and temporary forage (mainly oats, *Avena sativa* L.) were transplanted from

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The writer wishes to express appreciation to Drs. O. E. Sell and L. V. Crowder, of the Georgia Experiment Station, for their help and cooperation throughout the investigation.

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uncontaminated pastures to a greenhouse to make 24- and 32-inch square plots. Each plot in the greenhouse was enclosed by a wooden barrier to prevent the larvae from migrating from one plot to another.

The turfs were brought into the greenhouse several days in advance of the start of the experiment so that they would have time to become re-established. No attempt was made to control temperature, but the greenhouse was heated with gas burners and the average mean temperature during the experiments was 80°F.

During the experiments the plots were gently sprayed with water each morning (to simulate the dew that would normally collect on the forage under field conditions), care being taken to prevent the larvae from being washed from one area to another.

Each plot was contaminated by placing a mixture of infective larvae of cattle nematodes (mainly *Cooperia punctata,* but with some *Trichostrongylus axei, Ostertagia ostertagi,* and *Haemonchus contortus** also present) at its center, which was marked with a botanical marker. Plots of each forage were designated as 24-, 48-, or 72-hour plots, and forage clippings were taken at the end of each designated time interval.

In experiment 1 the fescue was inoculated in the morning and the clover and temporary forage in the afternoon. Each forage group was inoculated with a different number of larvae from a different culture. For experiments 2, 3, and 4 equal numbers of larvae were taken from the same culture for each of the experiments and inoculated into the plots at the same time.

A measuring apparatus was designed and built for the determination of the extent of lateral migration of the larvae on the forages. This apparatus consisted of eight graduated rings made of galvanized sheet metal (#26 gauge) 1½ inches wide soldered to a ⅛-inch galvanized wire cross. The rings were spaced 2 inches apart, the smallest ring having a radius of 2 inches and the largest a radius of 16 inches.

During the collections of forage samples, the measuring apparatus was placed on the plot and all the forage within each ring was clipped with a pair of scissors just above the ground surface, leaving a ¼- to ½-inch stubble. The clipped forage from each ring was placed in a separate, sterile, tightly covered metal container. No attempt was made to ascertain the horizontal distribution of the larvae on the forage or to collect larvae from the mat (when present), surface soil, or deeper soil, but generally some mat or earth was unavoidably scooped up with the cut forage and was included in each sample.

Forage samples were individually baermannized. Each sample container was carefully rinsed with approximately 240 ml. of warm water to remove any larvae that might have clung to its bottom or sides and this washing added to the proper Baermann funnel.

For the field studies 32-inch square plots of second year fescue, crimson clover on Bermuda sod, and temporary forage (mainly oats) were marked off on uncontaminated field forage plots and utilized for studying the lateral migration of the infective larvae under field conditions.

These studies were carried out in exactly the same manner as those in the greenhouse except that the plots were inoculated with *C. punctata* larvae only and the forage was not sprayed.

The greenhouse and field studies were conducted during the months of November and December of 1953 and January and part of February of 1954.

*The donor cattle probably harbored specimens meeting the criteria for both *H. placei* and *H. contortus* laid down by Roberts *et al.* (1954. Austral. J. Zool., 2: 275-295).

RESULTS AND DISCUSSION

The results of the four series of experiments are recorded in tables 1-4. The data in tables 1 and 2 show that when infective (third-stage) larvae of cattle nematodes, *C. punctata, T. axei, O. ostertagi,* and *H. contortus,** were introduced onto forage plots in a greenhouse, maintained at a temperature of around 80°F., some of the larvae migrated laterally as much as 16 inches in 24 hours on second year fescue, up to 12 inches in 48 hours on crimson clover, and up to 8 inches in 24 hours on temporary forage. The data in tables 3 and 4 show that under field conditions, with an average minimum temperature of 36°F. and an average maximum temperature of 64°F., infective larvae of *C. punctata* migrated up to 8 inches in 24 hours on second year fescue and temporary forage and up to 6 inches in 48 hours on crimson clover.

Because of the limited number of the experiments performed and the many variables that may have affected the results obtained, more definitive conclusions concerning lateral migration by infective larvae of cattle nematodes cannot be drawn from them.

That humidity, temperature, light intensity, and morphology of forage plants greatly influence vertical migration of trichostrongylid larvae has been shown by Mönnig (1930), Rogers (1940), Dinaburg (1942), Furman (1944b), and Rees (1950). These same factors undoubtedly influence lateral migration, too, though probably in somewhat different ways.

The inconsistencies that will be noted in the percentages of larval recovery and in the distances traversed by the larvae in the different comparable experiments (tables 1-4) and the differences between the distances traversed laterally by the larvae used in the greenhouse and in the field experiments here reported doubtless may be traceable in part to different combinations of the aforementioned factors. There is also the possibility that the larvae of *C. punctata,* used exclusively in the field experiments, do not migrate as far as those of other species included in the mixture used in the greenhouse experiments and that the morphology of the different forage plants may affect the number of larvae recovered by baermannization.

Though many questions still remain unanswered in regard to lateral migration, this investigation definitely showed that these infective larvae are capable of migrating much greater distances than has been indicated by previously published reports, and that, judging by the results obtained in the greenhouse, plots at least two and a half to three feet square should be used for ecological studies of these parasites.

SUMMARY

The lateral migration of infective-stage larvae of cattle nematodes on three different forages was studied in two experiments in a greenhouse and in two outdoor experiments. The extent of migration in 24, 48, and 72 hours was determined. In the indoor experiments, larvae of a mixture of common species of cattle parasites were used and some larvae migrated laterally as much as 16 inches. In the outdoor experiments only *Cooperia punctata* larvae were used, and none migrated laterally more than 8 inches. These larvae migrated greater distances than previous reports indicated they might. It is suggested that in further studies plots at least two and a half to three feet square should be used.

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*See footnote p. 100.

TABLE 1.—EXPERIMENT 1

Extent of Lateral Migration by Cattle Nematode Larvae of Mixed Species on Three Forages in First 72 Hours after Inoculation of Greenhouse Plots*

Larval Migration (Inches)	Larvae Recovered from— 2nd Year Fescue Plots[a]			Crimson Clover Plots[b]			Temporary (Oats) Plots[c]		
	24 Hours	48 Hours	72 Hours	24 Hours	48 Hours	72 Hours	24 Hours	48 Hours	72 Hours
0 - 2	5,700	1,500	2,733	1,600	356	386	20	120	63
2 - 4	3,533	600	233	166	163	140	50	30	16
4 - 6	9,433	225	86	13	143	40	0	10	16
6 - 8	3,166	153	150	6	14	20	0	0	0
8 - 10	413	160	76	3	10	3	0	0	0
10 - 12	0	396	316	0	34	36	0	0	0
Total larvae recovered	22,245	3,034	3,594	1,788	720	625	70	160	95
Per cent of recovery	52.9	7.2	8.5	9.9	3.6	3.1	1.7	4.0	1.1

*All forage samples baermannized for 6 hours.

[a]Each plot inoculated the same morning with 42,000 mixed infective larvae from the same culture.

[b]Each plot inoculated the same afternoon with 20,000 mixed infective larvae from the same culture.

[c]Each plot inoculated the same afternoon; the 24- and 48 hour plots each with 4,000 mixed infective larvae and the 72-hour plot with 8,500 mixed infective larvae from the same culture.

TABLE 2.—EXPERIMENT 2

Extent of Lateral Migration by Cattle Nematode Larvae of Mixed Species on Three Forages in First 48 Hours after Inoculation of Greenhouse Plots*[a]

Larval Migration (Inches)	Larvae Recovered from—					
	2nd Year Fescue Plots		Crimson Clover Plots		Temporary (Oats) Plots	
	24 Hours	48 Hours	24 Hours	48 Hours	24 Hours	48 Hours
0 - 2	2,500	2,570	300	2,200	230	1,500
2 - 4	300	800	180	1,700	70	860
4 - 6	40	100	30	170	90	100
6 - 8	30	70	30	120	410	150
8 - 10	200	20	20	30	0	0
10 - 12	20	100	0	60	0	0
12 - 14	20	40	0	0	0	0
14 - 16	50	80	0	0	0	0
Total larvae recovered	3,160	3,780	560	4,280	800	2,610
Per cent of recovery	7.7	9.3	1.3	10.3	1.9	6.4

*All forage samples baermannized for 24 hours.

[a] Each plot inoculated the same morning with 40,500 mixed infective larvae from the same culture.

TABLE 3.—EXPERIMENT 3

Extent of Lateral Migration by Infective Larvae of *Cooperia punctata* on Two Forages in First 72 Hours after Inoculation of Outdoor Plots**

Larval Migration (Inches)	Larvae Recovered from—					
	2nd Year Fescue Plots			Temporary (Oats) Plots		
	24 Hours	48 Hours	72 Hours	24 Hours	48 Hours	72 Hours
0 - 2	210	400	260	40	680	220
2 - 4	60	40	40	10	10	0
4 - 6	0	0	0	0	0	0
6 - 8	0	0	0	0	0	0
8 - 10	0	0	0	0	0	0
10 - 12	0	0	0	0	0	0
12 - 14	0	0	0	0	0	0
14 - 16	0	0	0	0	0	0
Total larvae recovered	270	440	300	50	690	220
Per cent of recovery	0.9	1.4	1.0	0.1	2.9	0.6

*All forage samples baermannized for 24 hours.
[a] Each plot inoculated the same morning with 30,000 *Cooperia punctata* infective larvae from the same culture.
Mean minimum temperature for 72-hour period 36°F. and mean maximum temperature 48°F.

TABLE 4.—EXPERIMENT 4

Extent of Lateral Migration by Infective Larvae of *Cooperia punctata* on Three Forages in First 72 Hours after Inoculation of Outdoor Plots*[a]

Larval Migration (Inches)	Larvae Recovered from—								
	2nd Year Fescue Plots			Crimson Clover Plots			Temporary (Oats) Plots		
	24 Hours	48 Hours	72 Hours	24 Hours	48 Hours	72 Hours	24 Hours	48 Hours	72 Hours
0 - 2	750	730	260	840	1,100	530	100	810	230
2 - 4	120	50	90	0	50	10	30	40	50
4 - 6	20	0	0	0	20	10	10	10	10
6 - 8	210	0	0	0	0	0	10	0	0
8 - 10	0	0	0	0	0	0	0	0	0
10 - 12	0	0	0	0	0	0	0	0	0
12 - 14	0	0	0	0	0	0	0	0	0
14 - 16	0	0	0	0	0	0	0	0	0
Total larvae recovered	1,100	780	350	840	1,170	550	150	860	290
Per cent of recovery	3.9	2.6	1.2	3.0	4.1	1.9	0.5	3.0	1.0

*All forage samples baermannized for 24 hours.

[a] Each plot inoculated the same morning with 28,000 *Cooperia punctata* infective larvae from the same culture. Mean minimum temperature for 72-hour period 36°F. and mean maximum temperature 64°F.

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The Occurrence of the Intestinal Threadworms, *Strongyloides ratti*, in the Tissues of Rats, Following Experimental Percutaneous Infection

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This paper summarizes data from post-mortem examinations of albino rats experimentally infected with the intestinal threadworm, *Strongyloides ratti*. Autopsies were performed one to 13 days after infection. The purpose was to ascertain, in relation to the time after infection, (a) the distribution of migrating threadworm larvae in the tissues, (b) the number of these larvae that could be recovered therefrom, and (c) the number of adult and preadult worms in the intestine.

The study herein reported was conducted during the period May through October, 1945. The work was done at Beltsville, Maryland, in the laboratory of the Zoological Division, Bureau of Animal Industry, now the Animal Disease and Parasite Research Division, U. S. Department of Agriculture. The following is a brief summary of (a) the method of conducting the investigation, and (b) the findings therefrom.

EXPERIMENTAL PROCEDURE

Three successive tests were carried out. The number of rats involved in each, the technique of infecting these animals with threadworms, and the method by which organs and tissues of the infected animals were examined for these parasites were the same in all tests.

EXPERIMENTAL ANIMALS: Thirty-nine half-grown male albino rats were used in the three tests, 13 in each. These animals were from a colony that was known to be free of intestinal helminths. Only healthy, vigorous animals of comparable ages and weights were used.

TECHNIQUES OF INFECTING AND MAINTAINING THE EXPERIMENTAL ANIMALS: Infections were administered by the percutaneous route; approximately 50,000 infective larvae per animal. The rat was anesthetized and the abdominal skin shaved, washed, and dried. The larvae, suspended in about 0.5 cc. of water, were then spread over the shaved area. The rat was kept under anesthesia until the skin became dry. By this time all but a minor proportion of the larvae had penetrated into the tissues. Drying was facilitated by application of moderate heat from a 50-watt bulb inserted into a reflector and held six to eight inches from the skin. After infection, each rat was isolated in an individual cage, equipped with a wire-mesh floor, that had been cleaned and sterilized prior to use. Fresh water and food, in sterilized containers, were provided for each animal daily.

TECHNIQUE OF AUTOPSY: In each test, beginning 24 hours after infection and continuing for a period of 13 days, one of the infected animals was autopsied at the end of each succeeding 24-hour period. The animal was killed by deep anesthesia, using chloroform or ether. The following procedures were then carried out in the order in which they are listed below.

1. The skin was removed. Then, by means of a stream of physiologic saline from a washing bottle, the serous surface of the skin and the entire carcass were washed to remove larvae that might be adhering thereto. These washings were collected in cone-shaped containers and allowed to "settle" overnight at room temperature, to concentrate the larvae.

2. The body was eviscerated and separated into six more or less distinct parts, herein designated as follows: "hind" (posterior) legs; "fore" (anterior) legs; head; loins (back muscles, dissected from the backbone and ribs); skin (the shaved area of the skin, on which larvae had been placed at the time of infection); and carcass, i.e., the remainder of the body of the animal after removal of the parts named above. Except in the case of the loins, no attempt was made to separate the muscle tissues from the skeleton.

3. The parts named above and the small intestine were each ground twice through a separate food chopper. Each lot of ground-up tissue was transferred to a separate 100-cc. Erlenmeyer flask that had previously been cleaned and sterilized. A small handful of clean glass beads and 50 cc. of sterilized physiologic saline (temperature, 37°C.) were added to each flask, which was then stoppered tightly and shaken vigorously for one to two minutes. The flasks were then maintained in a temperature of 37°C. during a period of four hours. During that time, each flask was shaken vigorously for one to two minutes at intervals of 15 minutes to assist in freeing larvae from the tissues.

4. The liver, lungs, gonads, and heart were minced separately by means of fine scissors, placed in separate flasks, and handled in the manner described above. Before the heart was comminuted, the auricles and ventricles were

Table 1. Numbers of intestinal threadworms (*Strongyloides ratti*) recovered post-mortem from tissues of experimental rats necropsied on successive days after experimental infection.*

Tissues Examined	Day 1 Number	Day 2 Number	Day 3 Number	Day 4 Number	Day 5 Number	Day 6 Number	Day 7 Number	Day 8 Number	Day 9 Number	Day 10 Number	Day 11 Number	Day 12 Number	Day 13 Number
Hind legs	284	2,649	2,214	1,852	635	735	1,219	170	45	0	28	0	17
Forelegs	32	2,131	1,265	4,986	1,748	1,816	1,879	1,216	28	414	1,293	7	36
Loins	34	266	1,349	1,507	429	138	579	90	0	0	14	0	0
Head	32	12,810	3,358	13,004	2,487	2,286	1,452	1,191	55	533	1,183	42	92
Carcass	14,880	3,097	4,697	22,267	6,003	3,498	3,647	2,530	42	55	601	0	226
Lungs	61	1,242	77	2,648	1,615	2,923	395	1,779	14	27	87	1	3
Heart muscles	0	0	0	29	6	41	37	2	0	0	0	0	1
Liver	0	0	0	108	1	10	15	0	0	0	1	0	0
Gonads	56	25	0	55	0	192	16	5	0	0	6	0	0
Intestine	0	135	28	681	9,100	1,587	12,993	13,222	18,511	9,108	4,847	13,570	8,540
Skin	0	464	420	1,466	232	121	1	0	0	0	0	0	0
Auricles/ ventricles	0	0	0	80	24	16	1	0	0	2	0	0	0
Subcutaneous area	2,701	2,811	435	2,776	364	614	350	433	0	64	83	0	0
Total	18,080	25,630	13,843	51,459	22,644	13,977	22,602	20,639	18,695	10,203	8,143	13,620	8,915

*The data constitute a summation of the findings from three tests, in each of which one rat was autopsied on each of 13 successive days after infection.

opened and washed out by means of a stream of physiologic saline; these washings were sedimented and later examined for larvae.

5. After the flasks containing tissue and saline had been incubated and shaken periodically during a period of four hours, the contents of each were poured through a sieve or screen (70 meshes per inch) to separate the larger particles of host tissue from the liquid. Material caught in the screen was washed thoroughly by means of a stream of saline under pressure to remove larvae that may have been adhering to the particles of host tissues or to the screen itself. The liquid that passed through the screen contained small shreds of host tissue and larvae in suspension. This suspension was collected in cone-shaped containers and sedimented at room temperature overnight (about 18 hours).

6. At the termination of the sedimentation period, the supernatant fluid in each container was decanted. Small quantities of the sediment were transferred to Syracuse Watch Glasses and examined microscopically for threadworms. If these parasites were numerous, the number was determined by a dilution count technique. If the number was small, all the sediment was examined. A dissecting microscope was used. It was found desirable to tilt the mirror of the microscope so that a portion of the microscope field was left in semidarkness. The threadworm larvae, which were small and quite transparent, could most easily be seen at the interphase of the light and dark areas.

In cases where the amounts of host tissue were quite large, it was advantageous to add a small amount of N/10 NaOH to the preparation at the time of examination. This chemical served to "clear" shreds of host tissue which might otherwise have obscured the larvae, but did not interfere with the activity of the larvae. Adult and preadult worms from the intestine were large enough to be seen without first "clearing" the preparation in which they were contained.

FINDINGS

As stated previously, a total of 39 rats was used in the three tests, 13 in each. For purposes of this report, the findings of the three tests are herein combined into a single table (Table 1) and treated as a unit. This is considered desirable because results of the second and third tests, with more or less minor variations, were repetitive of the first. Table 1 shows for the three tests combined the total number of larval and adult threadworms recovered from the tissues of rats (one rat per test, three for the entire experiment) autopsied each day after infection. The following points may be noted.

1. Threadworms were recovered from the carcasses of rats necropsied 24 hours after infection. In general, at that time, larger numbers were recovered from the posterior areas of the body than were recovered from the anterior portions. From the third day onward, however, the number of worms that were recovered from the anterior portions of the body generally exceeded the number recovered from the posterior parts.

2. Migrating threadworms were recovered from the lungs of animals killed the first day after infection; the maximum number recovered from this organ was obtained on the sixth day, after which, in general, the number declined.

3. Larvae were recovered in greatest numbers from the heart muscles and the liver of animals killed four to seven days, inclusive, after infection. In the case of the heart muscles, the maximum number was recovered on the sixth day.

4. In the case of animals autopsied from the second to the sixth day, inclusive, larvae were recovered from the skin, a fact which showed that some of the young worms had become trapped in the skin tissues at the time of infection. The maximum number was recovered on the fourth day, at which time the preparations of these tissues contained more than 1,000 of these young worms.

5. On the basis of the total number of threadworms (larvae and adults) recovered from the animals in question, the maximum occurred on the fourth day, at which time more than 50,000 were recovered. On the third and sixth days, however, the numbers recovered were comparatively small. The reasons for this variation are not apparent. Even 13 days after infection, some migrating worms were recovered from certain of the tissues examined.

6. Worms were recovered from the small intestine of animals autopsied two days after infection; the maximum numbers were recovered on the ninth and 12th days.

7. In the case of one animal autopsied 13 days after infection, one sexually mature *Strongyloides* was recovered from the lungs. This worm was alive and normal in appearance, and the reproductive tract was filled with eggs.

Discussion

In the investigation herein reported, the migratory behavior of the intestinal threadworm, *Strongyloides ratti,* in its rat host was similar to that observed for *S. ransomi* in pigs (Spindler and Hill, 1942; Spindler, Hill, and Zimmerman, 1943; and Spindler, 1944). Migrating larvae of *S. ratti* were recovered from various portions of the skeletal musculature of experimental rats as many as 13 days after percutaneous infection. These larvae, during the course of their migration from the abdominal skin, the site of infection, to their ultimate location, the small intestine, invaded the liver, gonads, and heart muscle. The presence of the young parasites in the heart muscles of the rat was not productive of death of the affected animal, as was observed in the case of swine (Spindler *et al., loc. cit.*).

Invasion of the musculature of the test rats by the migrating threadworms was associated with a number of symptoms, namely, bleeding from the nose and around the eyes, reddening of the ears, reluctance to move, irritability, and soreness and stiffness of the muscles. Some of these same symptoms, in varying degrees of severity, were previously observed in pigs infected with *S. ransomi.*

As can be seen from the data, there was, after infection, a rather high concentration of threadworms in the musculature of the test rats, with a comparatively small number of these worms in the intestine. As the number in the intestine increased, the number recovered from the muscles decreased, more or less proportionately. The findings seem to indicate that within a few hours after infection the young threadworms became widely dispersed throughout the body. Then, as migration progressed, the organisms became concentrated in the small intestine. If this postulation is the correct one, it may provide in part an explanation of the course of egg production by threadworms. It is known that after the first appearance of eggs of this parasite in the feces, the number eliminated may increase rapidly until about the ninth to the 12th days after infection, after which the number of eggs may decrease rapidly. As can be seen from Table 1, the maximum number of worms recovered from the intestine occurred on the ninth day.

A noticeable feature of the data is the fact that in most cases only a small proportion of the larvae administered to the test rats was recovered by subsequent examination. This may be accounted for in several ways. It is recognized that the technique which was used for recovering larvae from tissues was inherently faulty in many respects. Probably it was not possible by the technique used to comminute the tissues finely enough to effect release of all the larvae contained therein. In addition, numerous larvae were probably lost during the process of sedimentation. The young worms at the stage of development in which they occurred in tissues were very light and settled slowly in liquid. Moreover, many of the young worms, because of their small size and transparent condition, may have been overlooked in the examinations. It is almost certain also that sizable numbers of the young worms probably died in the tissues. While the vast majority of the larvae recovered was alive and active, some dead ones were recovered from time to time. Undoubtedly, the tissues contained many more dead ones than were recovered. Inasmuch as recovery of the young worms depended, in part, on their ability to free themselves from the ground-up tissues, dead larvae would be recovered only by chance.

Of interest is the fact that larvae were recovered from the gonads on numerous occasions. In investigations on swine infected with *S. ransomi* some evidence, as yet unpublished, was obtained which indicates that the ability of some of these animals to breed was impaired to a certain extent at least.

SUMMARY

1. After infection through the skin, larvae of *Strongyloides ratti* could be recovered from skeletal muscles, heart, liver, and gonads, as well as from the lungs of rats.

2. In rats killed 24 hours after infection, larvae were most abundant in the posterior portions of the body, less abundant in the anterior portions. By the fourth day, the situation was reversed.

3. As the larvae completed their migration through the lungs to the intestine, the number that could be recovered from the musculature decreased, more or less proportionately.

4. The maximum number of adult and preadult worms recovered from the intestine was found in rats killed nine days after infection.

5. Some larvae were recovered from certain of the tissues of rats killed 13 days after infection.

6. A living sexually mature female was recovered from the lungs of an rats autopsied on the 13th day after infection.

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A Redescription of *Anatrichosoma cynamolgi* Smith and Chitwood, 1954*

M. B. Chitwood and W. N. Smith**

In February 1954, one of the writers (W.N.S.) found three female specimens of a new trichuroid nematode in the nasal passages of *Macaca philippinensis* (syn. *Cynamolgus philippensis*) from a colony of monkeys maintained at the National Institutes of health, Bethesda, Maryland. The nematodes were found loosely coiled in well-defined tunnels beneath the mucous lining of the nasal septa near the external nares. Additional specimens, including two males, were recovered from the same location in subsequent examinations of other monkeys of the same genus. The monkeys were from one to three years old and had been shipped from the Philippines for polio studies. The worms were collected through the courtesy of Dr. Bernice E. Eddy of the National Institutes of Health.

This nematode conforms to the characters of the superfamily Trichuroidea and is apparently a transitional form between the Capillariidae and Trichosomoididae, with somewhat closer affinities to the latter, and for it the writers (Smith and Chitwood, 1954) erected the genus *Anatrichosoma*, with *A. cynamolgi* as type species. Since the nematode was inadequately described in abstract, the purpose of this present paper is to make available in the literature a more complete description, together with illustrations of the parasite.

Anatrichosoma Smith and Chitwood, 1954

Generic diagnosis: Anatrichosomatinae. Small, slender, threadlike nematodes; stylet present in both sexes (Fig. 2 A-B). Esophageal region 1/6 to 1/3 body length.

Female: Body tapering from anterior end to posterior region, constricting at base of esophageal region; cephalic cuticular inflation present (Fig. 1, A); vulva posterior to postesophageal constriction, prominent, without appendage.

Male: Body filiform, cephalic cuticular inflation absent (Fig. 1, B); spicule and copulatory sheath absent.

Type species: *Anatrichosoma cynamolgi* Smith and Chitwood, 1954.

Other species: *Anatrichosoma cutaneum* (Swift, Boots, and Miller, 1922) n. comb.

Anatrichosoma cynamolgi Smith and Chitwood, 1954

Specific diagnosis: *Anatrichosoma*. Head surrounded by circle of 10 papillae (Fig. 1, C), two in each quadrant and one medioventral to amphids; lips absent, oral opening dosoventrally elongate. Nerve ring just behind cephalic inflation; preglandular esophageal swelling elongate, 126-132 stichocytes; well-developed esophagointestinal valve enclosed in anterior intestinal enlargement; intestine narrow, ending in large swollen rectum; anus terminal. Cuticle thick, transparent, very flexible, with fine longitudinal striations and two broad lateral bacillary bands extending most of body length.

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FEMALE: 17.8–19.6 mm. long; anterior end 0.048–0.052 mm. wide; body widening gradually to base of esophagus (0.165 mm. at widest point), then constricting sharply unilaterally (0.11 mm.) just anterior to vulva (Fig. 2, C-D), and again widening gradually to maximum width near posterior end of body; tail conical (Fig. 2, E). Vulva prominent, suckerlike, 5.56 mm. from anterior end of body, reproductive system in linear arrangement except for multicoiled oviduct (Fig. 3, C-F). Ovary mostly tubular beginning with narrow vermiform germinal zone, which protrudes into tubular part. Eggs: 0.045–0.057 mm. by 0.070–0.075 mm. (Fig. 2, D).

MALE: 18.6–20.7 mm. long; 0.09 mm. wide; width almost uniform, body tapering from head to tail region. Tail blunt, bearing at least four pairs of papillae, one pair ventrosubterminal, three pairs of sublateral papillae, with middle pair much larger. (Fig. 1, D). Spicule and copulatory sheath absent.

HOST: *Macaca philippinensis.*

LOCALITY: Philippine Islands.

HOLOTYPE, female: U.S.N.M. Helm. Coll. No. 47288.

OTHER SPECIMENS: U.S.N.M. Helm. Coll. No. 47289, males and females.

Trichosoma cutaneum Swift, Boots, and Miller. 1922, also from a monkey, is very similar, and the writers hereby transfer it to the genus *Anatrichosoma,* with the synonymy as follows: *A. cutaneum* (Swift, Boots, and Miller, 1922); *Trichosoma cutaneum* Swift, Boots, and Miller, 1922; *Capillaria cutanea* (Swift, Boots, and Miller, 1922) Freitas and Lent, 1936; *Eucoleus cutaneus* (Swift, Boots, and Miller, 1922) Lopez-Neyra, 1947.

Anatrichosoma cynamolgi may be distinguished from *A. cutaneum* in that the former is smaller in size but has larger eggs, the operculae of which are less prominent; *A. cynamolgi* has more stichocytes, the postesophageal swelling is unilateral and the vulva is suckerlike. The male of *A. cutaneum* is unknown.

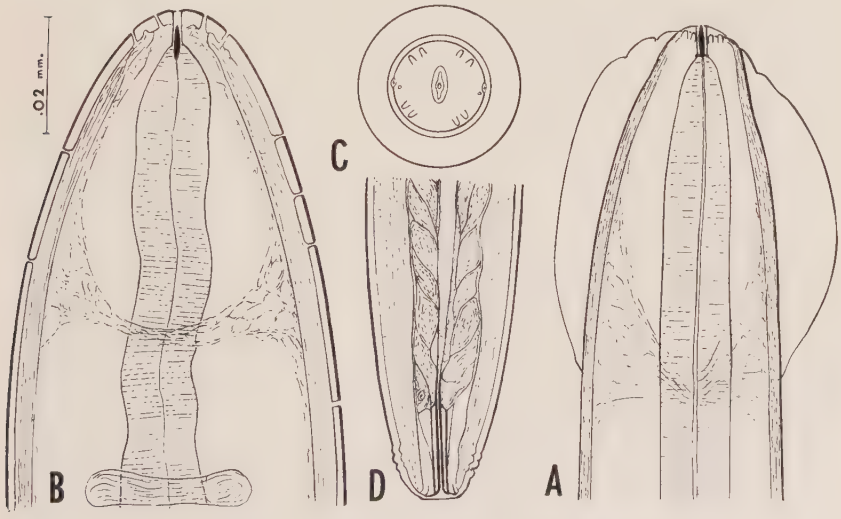
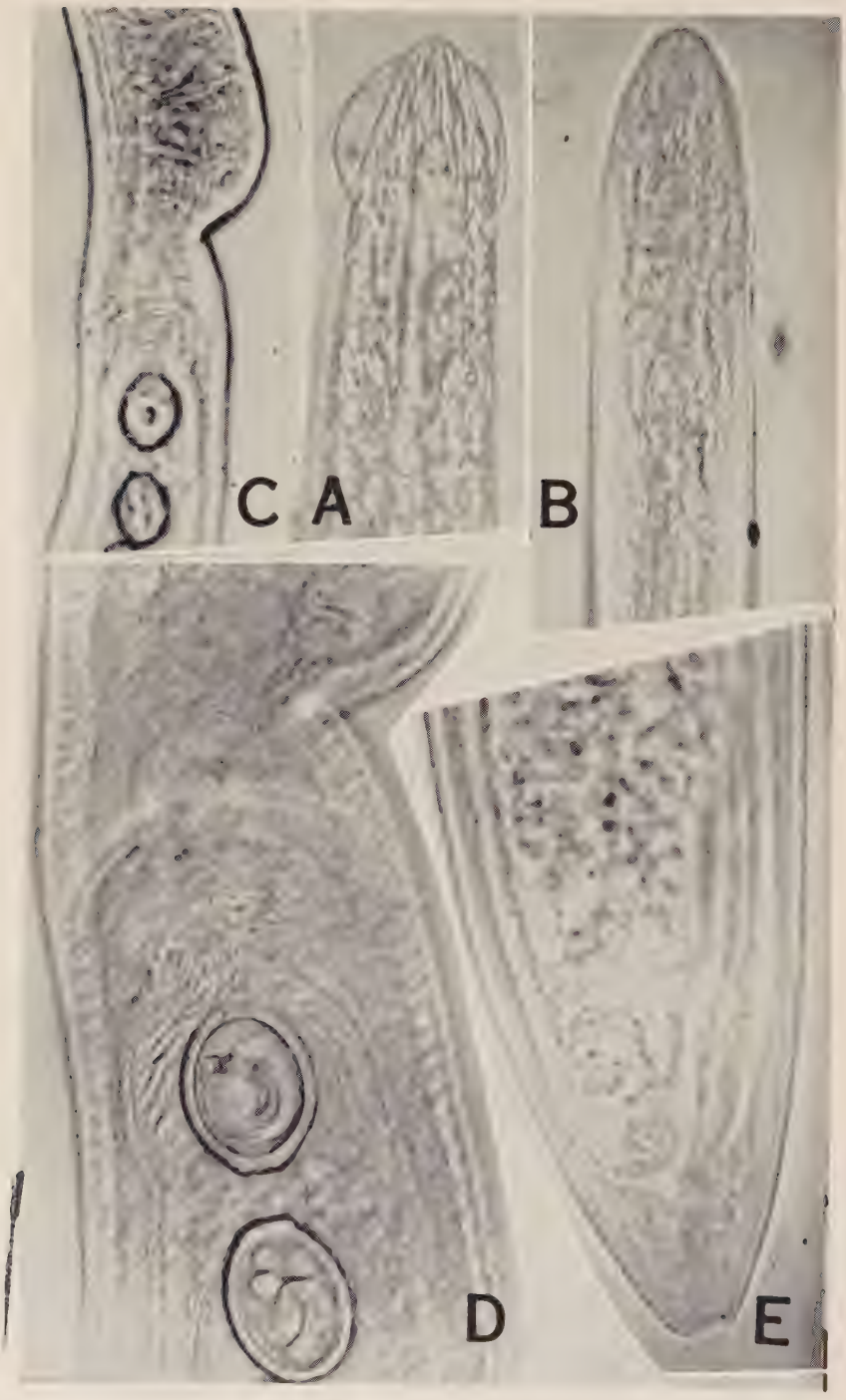


Fig. 1, A-D. *Anatrichosoma cynamolgi.*

A. Female, anterior end.
B. Male, anterior end.
C. Female, *en face* view.
D. Male, posterior end.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DISCUSSION

A. cutaneum was described by Swift, Boots, and Miller (1922) from female specimens recovered from cutaneous lesions on the hands and feet of *Macacus rhesus* (= *M. mulatta*) in a colony maintained by the Rockefeller Institute for Medical Research in New York City. Although these authors considered, primarily, the pathology of the lesions, their paper contains an adequate description of a female nematode and some excellent photographs. They were not nematologists and failed to recognize, with certainty, the males. They did, however, recognize that there were differences among their specimens and established that there were no males within the uterus of the females. Being unable to locate the nematode in the proper genus, they placed it provisionally "in the collective genus *Trichosoma* which is *Capillaria sensu lato*" on the theory that, when a male specimen was found, a more precise generic location could be determined. In the ensuing 32 years, no further report of this nematode appeared despite the widespread use of the host as a laboratory experimental animal. A single specimen of *Trichosoma cutaneum* was forwarded to Dr. C. W. Stiles by Swift, Boots, and Miller and was deposited in the U. S. National Museum Helminthological Collection as No. 11883. After comparing this specimen with specimens of *Anatrichosoma cynamolgi,* the writers were able to confirm that the two species are congeneric.

Specimens of *Anatrichosoma* sp. have recently been found in the nose of the rhesus monkey by Dr. Anton Allen, National Cancer Institute, Bethesda, Maryland. One of the writers (M.B.C.) has examined sections (Fig. 3, A-B) of this nematode in tissue, and some fragments, with the resulting conclusion that it is conspecific with the specimen of *A. cutaneum.* The eggs of Dr. Allen's specimens agree in size and shape with those shown in photographs by Swift, Boots, and Miller (*loc. cit.*).

The males of *Anatrichosoma* are unlike those of any other member of the super-family. Like *Trichosomoides, Anatrichosoma* males have neither spicule nor copulatory sheath. Unlike *Trichosomoides,* however, the males of *Anatrichosoma* are as long as, or longer than, the females of the same species and have never been observed within the uterus of the females. The presence of a well-developed seminal vesicle filled with elongate spermatozoa, which match those spermatozoa found within the uterus of the female, definitely establishes the sexual maturity of the males. No evidence of degeneracy of structure appears to characterize the anatrichosomes, and if the lack of male copulatory organs is evidence of neoteny, certainly these nematodes have developed beyond the stage attained by the tiny males of *Trichosomoides.* Although the writers do not normally subscribe to the practice of creating monotypic major groupings, the practice is so firmly established in the Trichuroidea that any changes merely add to the confusion. For this and the foregoing reason the following subfamily was proposed:

Fig. 2, A-E. *Anatrichosoma cynamolgi.*
A. Female, anterior end.
B. Male, anterior end.
C. Female, showing constriction in region of vulva.
D. Same as C, with greater magnification, showing eggs.
E. Female, posterior end showing terminal anus and coiled germinal zone of ovary.

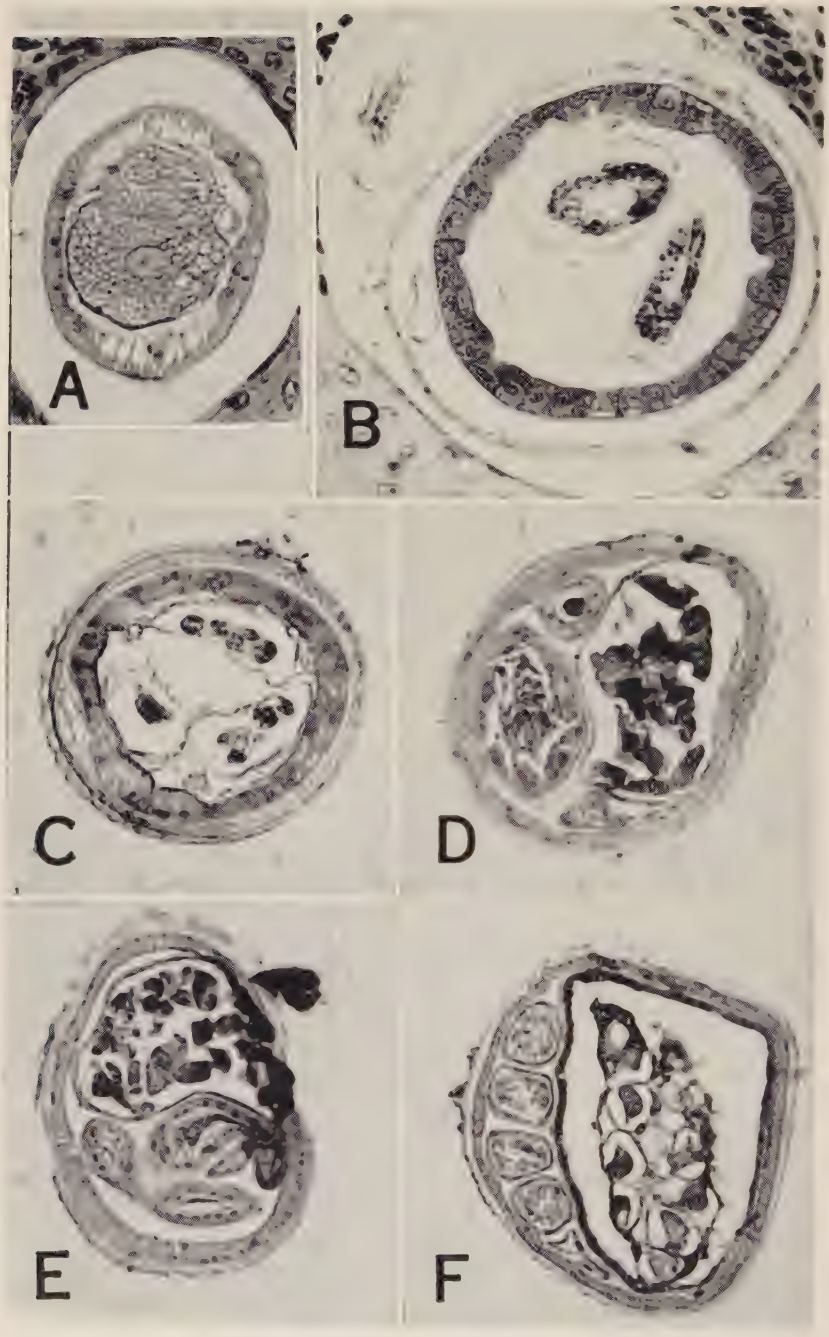
A
B
C
D
E
F

Fig. 3, A-B. *Anatrichosoma cutaneum* in nasal tissue of *Macaca mulatta*.
A. Section through esophageal region showing stichocyte, esophagus and bacillary glands.
B. Female, through uterus and through an egg outside of body.
Fig. 3, C-F. *Anatrichosoma cynamolgi*. Sections through female reproductive system.
C. Through uterus.
D. Through ovary, uterus, and oviduct.
E. Through convolutions of oviduct just before its entry into uterus.
F. Through uterus and four sections of oviduct.

Anatrichosomatinae Smith and Chitwood, 1954

DIAGNOSIS: TRICHOSOMOIDIDAE. Esophageal region shorter than remainder of body. Males without spicule or copulatory sheath, not inhabiting uterus of female. Females oviparous, eggs large, bioperculate, containing well-developed larva when deposited.

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A Review of the Taxonomy of the Trematode Genera *Ascocotyle* (Looss) and *Phagicola* (Faust) of the Family Heterophyidae

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The taxonomy of the class Trematoda is presently, and has been for years, in a state of transition and refinement. Explanations of such transition may be found in the following: 1) the recent emergence and establishment of the sub-science of parasitology; 2) the incomplete knowledge of trematode life histories; 3) intraspecific variation; and 4) technical difficulties.

The last point can be summarized by quoting Stunkard (1957):

> "In such variable worms, which have no skeletal structure, and in which the shape is modified by the contraction of different sets of muscles; which may become sexually mature at one-fourth the maximum size and continue to grow as long as they live; in which the morphology is dependent on the degree of maturity; and in which the location and shape of organs are influenced by extension and contraction of the body, by accumulation of genital products (spermatozoa in the seminal vesicle or eggs in the uterus), or even by accumulation of fluid in the excretory vesicle; specific determination of a particular individual may pose an almost insoluble problem."

In view of the present inadequacy of the systematics of the class, continued efforts must be made to build upon past inquiry and organization in order that the many groups might be kept "up-to-date." Meanwhile, as exemplified by La Rue (1957), one can only make the most of the framework established by his predecessors.

Discussion

Looss in 1899 described the genus *Ascocotyle;* the diagnosis of the genus being as follows:

> Body thickly spinose. Oral sucker with one or two rows of spines and with a distinct posterior muscular projection. Prepharynx long, pharynx well developed. Esophagus may or may not be present; intestinal ceca variable in length. Depression on ventral surface of body containing the genital sinus and the acetabulum. Testes paired posteriorly. Seminal vesicle very prominent and well developed. Ovary pretesticular median or slightly to one side. Seminal receptacle large, behind or on level with ovary. Vitellaria lateral, usually postacetabular. Uterus usually confined to postacetabular region. Eggs large, operculate.

Faust (1920) examined a collection of distomes from *Pithecophaga jeffreyi* (monkey-eating eagle) and concluded that they were sufficiently different from all existing heterophyids to warrant the establishment of a new subfamily (Phagicolinae) and genus (*Phagicola*). He cited the following as characteristic of the subfamily:

> Minute distomes with spinous body and an uninterrupted circlet of spines on the inner margin of the oral sucker. Ceca short, not surpassing acetabulum. Excretory bladder intermediate type between "V" and "Y" forms. Vitellaria postacetabular, consisting of a few large follicles. Testes unlobed, slightly oblique; far postacetabular. Ovary, seminal receptacle, and seminal vesicle postacetabular. Cirrus sac and prostate glands lacking; cirrus tube nonmuscular. Genital pore antacetabular. Type and sole genus, *Phagicola;* type species, *P. pithecophagicola.*

Stunkard and Haviland (1924) split the genus *Ascocotyle* into two subgenera, *Ascocotyle* and *Parascocotyle.* This was based on differences observed between *Ascocotyle coleostoma,* the type of Looss' genus, and a second species that Looss had described and assigned to the genus in the same paper, *A. minuta.* They listed the differences between these two species and stated that *minuta* appeared to constitute a distinct section of the genus, proposing the name *Parascocotyle* with *minuta* as the type.

Following Stunkard and Haviland's work, Faust and Nishigori (1926) considered *Phagicola pithecophagicola* to be a species of *Ascocotyle,* thus apparently invalidating the subfamily Phagicolinae and genus *Phagicola.*

Much confusion resulted from the fact that the original description of *pithecophagicola* failed to indicate the presence of a posterior oral projection and gonotyls, which would have established its position in the heterophyids. Wintenberg (1929) recognized *Parascocotyle* of Stunkard and Haviland as valid, and suggested that a redescription of new material of *pithecophagicola* could settle the differences of opinion concerning whether the subgenus *Parascocotyle* was synonymous with the genus *Phagicola,* or whether each represented a valid genus.

Price (1932) examined the type specimens of *pithecophagicola,* which Witenberg had assigned to the subgenus *Parascocotyle,* and definitely demonstrated the presence of a posterior oral projection and a bipartite gonotyl. He thus made apparent the synonomy of *Phagicola* and *Parascocotyle,* and established the former as the valid name according to the law of priority. Price considered *Phagicola* sufficiently different from *Ascocotyle* to accord it generic rank, and referred the following species to the group: *Phagicola pithecophagicola* Faust, 1920, *P. minuta* (Looss, 1899), *P. ascolonga* (Witen-

berg, 1929), *P. longa* (Ransom, 1920), *P. arnaldoi* (Travassos, 1928), *P. italica* (Alessandrini, 1906), *P. piriforme* (Blanc and Hedin, date and publication uncertain—now nomen dubium), *P. angrense* (Travassos, 1916), *P. nana* (Ransom, 1920), *P. diminuta* (Stunkard and Haviland, 1924), and *P. angeloi* (Travassos, 1928).

Again in 1935 Price pointed out that the species constituting the *Ascocotyle-Phagicola* complex readily lend themselves to two groupings, and maintained that the two groups should be regarded as valid genera. His evidence for this was based on the following differentiating characters:

Ascocotyle	*Phagicola*
1. Two rows of spines in oral coronet.	1. Single row of spines in oral coronet.
2. Cuticula entirely spinous.	2. Cuticular spines absent in posterior region of body.
3. Uterus extending beyond level of genital aperture.	3. Uterus not extending beyond level of genital aperture.
4. Vitellaria extending into preovarial region.	4. Vitellaria confined to post-ovarial region.

Srivastava (1935), in describing *Ascocotyle intermedius*, indicated that this species "connected" the genera of Price with reference to the extent of the viltellaria. Just what was meant by this is vague, for the vitellaria in *intermedius* extend beyond the ovary to the posterior level of the pharynx. This character would have placed it in Price's (1935) revision of *Ascocotyle* (s. str.).

Srivastava, however, regarded *Ascocotyle* and *Phagicola* as subgenera, placing *intermedius* in the subgenus *Phagicola* on grounds that it had a long esophagus, long intestinal ceca, and uterine coils confined posterior to the genital sinus. In his description of the species he refers to the esophagus as being short. This would not correspond to a criterion by which he attempted to show that *intermedius* belonged in the subgenus *Phagicola.* The other *characters* used by Srivastava as a basis for placing *intermedius* in the proposed subgenus were also invalid as such. *A. mcintoshi* Price, 1935, possesses long intestinal ceca terminating in the region of the testes, and several species of *Ascocotyle* have the greater part of the uterus confined to the region posterior to the genital sinus.

In view of the inter-generic variability of the characters by which Srivastava attempted to justify placing *intermedius* in the *Phagicola* group, the species was retained in the genus *Ascocotyle.*

In 1936 Price deleted the extent of the uterus as a differentiating character in his separation of the genera. This was done because he recognized *A. intermedius* as an exception to this character. He further stated that he regarded *Ascocotyle* and *Phagicola*

> ". . . as better established genera than some of the other genera of heterophyids, as well as many genera of other families, the validity of which rests largely upon a single character which in many cases is decidedly variable."

Recent translation of descriptions of *P. angeloi* (Travassos) and *P. arnaldoi* (Travassos) published in 1928 seem to contradict characters used by Price to distinguish the genus *Phagicola* from the genue *Ascocotyle.* The characters in question are the arrangement of the oral spines and the distribution

of the cuticular spines. According to Price a species of the genus *Phagicola* is characterized by a single row of oral spines and a posterior body region devoid of cuticular spines.

P. angeloi possesses two complete rows of spines in the oral coronet (14 in each row). It may be pointed out here that *P. nana* (Ransom, 1928) and *P. langeniformis* (Chandler, 1941) may be considered "intermediates" as regards the oral spines in Price's criteria, for *P. nana* was described as having spines arranged dorsally in a double and ventrally in single row, and *P. langeniformis* possesses a single complete circle of spines with two spines situated more posteriorly on the dorsal surface.

P. angeloi, and in addition, *P. arnaldoi,* were described as having entirely spinous cuticles, even though those spines on the anterior region of the body were determined to be slightly longer.

Since the aforementioned exceptions occur, the arrangement of the oral spines and the distribution of the cuticular spines can no longer be considered valid generic characters. This leaves only the extent of the vitellaria to separate the two groups.

Lal (1939) stated that there was much variability in the extent of the esophagus and intestinal ceca within the complex, indicating that the two groups should be combined into a single genus.

It is true that there are variations of the characters mentioned by Lal, just as there are variations in the arrangement of the oral spines, the distribution of the cuticular spines. and the extent of the uterus—none of these lending themselves to a justifiable separation of the entities of the complex into two distinct genera. In view of this there is something in favor of uniting the species under a single genus.

Nevertheless, further consideration indicates that such a revision would fail to solve the problem, and quite to the contrary, might only result in greater confusion. So the remaining differentiating character of the original four advanced by Price is the extent of the vitellaria, and should be regarded as valid until new analyses unquestionably warrant revision of the complex.

As there is need of new taxonomic keys for the genera, such an effort has been made. Construction of the keys presented in this paper resulted from study of original descriptions and illustrations, type specimens on deposit at the U. S. National Museum and, in at least two cases, living material.

Finally, it seems apparent that the species comprising the genus *Ascocotyle* are more likely to be valid than some of those making up the genus *Phagicola.* Several of the specific descriptions of the latter group are based on single specimens, and the descriptions of *P. minuta* (Looss, 1899), *P. italica* (Alessandrina, 1906), and *P. angrense* (Travassos, 1916), are incomplete in many respects. Studies of additional material, especially living specimens, will do much to ascertain the position of these species.

Summary

The taxonomy of the trematode genera *Ascocotyle* (Looss) and *Phagicola* (Faust) is reviewed. It is shown that the separation of the genera rests upon a single character, the extent of the vitellaria. In *Ascocotyle* the vitellaria extend anteriorly beyond the level of the ovary, whereas in *Phagicola* the vitellaria are restricted to the postovarial region.

Taxonomic keys are presented for each genus.

A KEY TO THE GENUS *ASCOCOTYLE*

1. (2) Body pyriform 3
2. (1) Body shaped like a tall beaker ..... *A. megalocephala* Price, 1935
3. (4) Vitellaria restricted to postpharyngeal region 5
4. (3) Vitellaria extending anteriorly to posterior level of pharynx. ..... *A. intermedius* (Srivastava, 1935) Price, 1936
5. (6) Intestinal ceca terminating anterior to testes 7
6. (5) Intestinal ceca extending posteriorly to anterior margin of testes ..... *A. mcintoshi* Price, 1936
7. (8) Oral coronet with less than 48 total spines 9
8. (7) Oral coronet with 48 to 52 total spines (24-26 in each of two rows ..... *A. leighi* Burton, 1956
9. (10) Oral coronet with 32 total spines (16 in each of two rows) 11
10. (9) Oral coronet with 36 total spines(18 in each of two rows). ..... *A. filippei* Travassos, 1928
11. (12) Uterine coils extending into posttesticular region 13
12. (11) Uterine coils confined to pretesticular region ..... *A. coleostoma* Looss, 1899
13. (14) Vitellaria extending anteriorly to posterior level of acetabulum. Apex of posterior oral projection lying 1/3 to ½ distance between oral aperture and pharynx ..... *A. puertoricensis* Price, 1935
14. (13) Vitellaria extending anteriorly to level of genital opening. Apex of posterior oral projection lying more than ½ distance between oral aperture and pharynx ..... *A. tenuicollis* Price, 1935

A KEY TO THE NORTH AND SOUTH AMERICAN SPECIES OF THE GENUS *PHAGICOLA*

1. (2) Uterine coils confined to postacetabular region 3
2. (1) Uterus with a few coils anterior to acetabulum ..... *P. angrense* (Travassos, 1916) Price, 1932
3. (4) Totality of spines in oral coronet in single complete circle 9
4. (3) Totality of spines in oral coronet not in single complete circle 5
5. (6) Oral coronet with 16 to 20 spines 7
6. (5) Oral coronet with more than 20 spines (two rows; 14 in each) ..... *P. angeloi* (Travassos, 1928) Price, 1932
7. (8) Oral coronet with 16 spines in a single complete circle and with 2 spines situated more posteriorly on dorsal side. ..... *P. langeniformis* Chandler, 1941
8. (7) Oral coronet with 16 to 20 spines situated dorsally in a double and ventrally in a single row ..... *P. nana* (Ransom, 1920) Price, 1932
9. (10) Intestinal ceca terminating near posterior margin of acetabulum 11
10. (9) Intestinal ceca extending beyond posterior margin of acetabulum 13
11. (12) Oral coronet with 18 to 20 spines ..... *P. minuta* (Looss, 1899) Price, 1932
12. (11) Oral coronet with less than 18 spines (about 16) ..... *P. diminuta* (Stunkard and Haviland, 1924) Price, 1932
13. (14) Oral coronet with 16 spines 15
14. (13) Oral coronet with 18 spines ..... *P. macrostomus* Robinson, 1956
15. (16) Gonotyl bipartite 17

16. (15) Gonotyl single ..... *P. byrdi* Robinson, 1956
17. (18) Cuticula entirely spinous; vitelline follicles 9-12 in each lateral field ..... *P. arnaldoi* (Travassos, 1928) Price, 1932
18. (17) Cuticula spinous on anterior body region only; vitelline follicles 2-6 in each lateral field ..... *P. longa* (Ransom, 1920) Price, 1932

Species described from Eastern Hemisphere not included in key: *P. italica* (Alessandrini, 1906) Price, 1932, *P. pithecophagicola* Faust, 1920, *P. ascolonga* (Witenberg, 1929) Price, 1932, and *P. longicollis* Kuntz and Chandler, 1956.

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Clavaurotylenchus minnesotensis, n. gen., n. sp. (Tylenchinae: Nematoda) from Minnesota

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A study of soil and plant parasitic nematodes associated with sugar beet crops was conducted in the North Western and North Central States. Among the nematodes collected in Minnesota were specimens belonging to Tylenchinae but of a new genus.

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The assistance and cooperation of the officials of Agricultural Research Service of the United States Department of Agriculture and the officials and personnel of the beet sugar industry which helped to make this study possible is gratefully acknowledged.

Clavaurotylenchus, n. gen.

DESCRIPTION: Tylenchinae. No sexual dimorphism. Body nearly cylindrical. Head continuous with body contour, without sclerotized framework. No striations on lip region. Cuticular annulation distinct. Stylet delicate with small basal knobs. Lateral fields with 4 incisures. Phasmids conspicuous, located near middle of tail. Vulva slightly post-equatorial in position, transverse. Ovary one, anterior to vulva, outstretched. Post-vulvar rudimentary branch short. Female tail slightly clavate, terminus hemispherical. Male tale conoid. Bursa envelops tail. Spicula and gubernaculum tylenchoid.

DIAGNOSIS: *Clavaurotylenchus,* n. gen., differs from *Tylenchus* Bastian, 1865, in having a non-striated lip region and the hemispherical clavate tail, *Clavaurotylenchus,* n. gen., can be separated from *Tylenchorhynchus* (Butschli, 1873) Filipjev, 1936, by having a delicate stylet, a non-striated lip region and a single anterior ovary. *Clavaurotylenchus,* n. gen., is distinguished from *Tetylenchus* Filipjev, 1936, and *Psilenchus* de Man, 1921, by having one ovary and the shape of the tail. *Clavaurotylenchus,* n. gen., differs from *Ditylenchus* Filipjev, 1934, in the more anterior position of the vulva and the shape of the tail.

TYPE SPECIES: *Clavaurotylenchus minnesotensis,* n. gen., n. sp.,

Clavaurotylenchus minnesotensis, n. sp. (Fig. 1 A-D)

MEASUREMENTS: 10 females, L = 0.754 mm. (0.668-0.845 mm.); a = 30.9 (26.2-34.3); b = 5.7 (5.3-6.3); c = 18.1 (16.7-22.2); V = $^{29}58\%$ ($^{26\text{-}32}55.8$-60.7%); stylet 14-15 microns long. Male, L = 0.732 mm., a = 34.9, b = 5.6, c = 34.9, T = 38.1%, stylet 14 microns long.

FEMALE (HOLOTYPE). Body cylindrical, tapering at anterior end. Lip region bluntly conoid, continuous with body contour, annules wanting. Sclerotized labial framework lacking. Stylet 14 microns long, delicate, with small rounded knobs. Orifice of dorsal esophageal gland 2.3 microns behind stylet base. Median esophageal bulb elongate-ovate, small. Excretory pore opening slightly posterior to nerve ring. Esophageal-intestinal valve moderate. Vulva slightly post-equatorial. Ovary one, anterior to vulva, outstretched. Length of post-uterine sac slightly more than ½ body width at vulva. Spermatheca with spermatoza present. A post-anal extension of intestinal sac present. Tail slightly clavate, terminus hemispherical, smooth, annulation of cuticle not extending around terminus. Length of tail 3.5× anal body diameter. Cuticle finely striated. Annules about 1.05 wide at middle of body. Lateral field with 4 incisures, occupying ⅜ of body width. Phasmids distinct, opening slightly posterior to middle of tail.

MALE (ALLOTYPE). Similar to female. Stylet 14 microns long. Phasmids opening at posterior ⅔ of tail. Bursa envelops tail. Spicules 20 microns long, tylenchoid. Gubernaculum 9 microns long, slightly curved with a slight thickening just anterior to middle.

HOLOTYPE—FEMALE: Collected August 26, 1957 by Gordon A. Olson. Type Collection of Nematology Section, U. S. Department of Agriculture, Beltsville, Maryland.

ALLOTYPE-MALE: Same collector and date as for holotype. Type Collection of Nematology Section, U. S. Department of Agriculture, Beltsville, Maryland.

PARATYPES—12 FEMALES: Type Collection of Nematology Section, U. S. Department of Agriculture, Beltsville, Maryland.

HABITAT: Soil about roots of sugar beets, *Beta vulgaris* L.

TYPE LOCALITY: Climax, Minnesota. Polk county, Range 49, Township 149, Section 12W².

Specimens of this species were examined from Thompson, North Dakota, Ada and Alvarado, Minnesota.

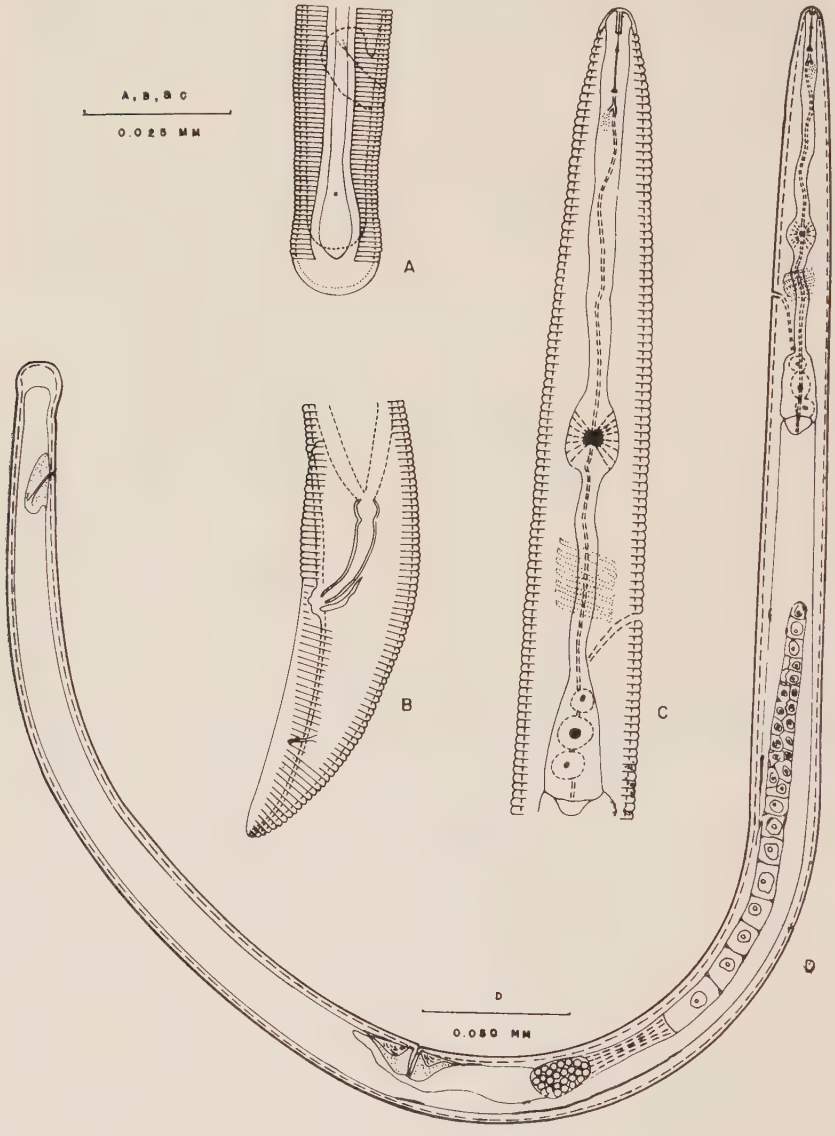

Figure 1. *Clavaurotylenchus minnesotensis*, n. gen., n. sp. A. Posterior portion of female. B. Posterior portion of male. C. Anterior portion of female. D. Adult female.

Four New Species of *Hemicycliophora* de Man, 1921, with Further Observations on *H. brevis* Thorne, 1955 (Nematoda: Criconematidae)

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Numerous specimens of a nematode species belonging to the genus *Hemicycliophora* de Man, 1921 were recovered by the writer from soil collected about the roots of a cajeput tree, *Melaleuca leucadendra* L., on Feb. 4, 1956, near Lakeland, Florida. In the collection males were almost as abundant as females, which was notable since males have been known in only two species, *H. typica* and *H. penetrans*. The specimens were also distinctive because of their similarity to *H. typica*, the type of the genus. These nematodes were compared with specimens of *H. typica* designated as types by Thorne (1955) from nematodes collected in Zeeland, Netherlands, and important differences were noted in the shape of the tail and the wider annulation of the females as well as in the lateral field and the length and shape of the tail of male specimens. On the basis of these differences the specimens are considered to represent a new species for which a description is presented.

More recently males have been found for two other species in this genus from collections made in California. Males of *H. brevis* were recovered along with female specimens by S. A. Sher on July 1, 1957, from soil about the roots of oak near Santa Barbara, Calif. *H. brevis* was described from a single female and material from the above collection is used here to further define the species including a description of the male. In another collection males and females of *Hemicycliophora* described here as a new species were found in abundance in soil from a citrus planting near Mecca, Calif., on Oct. 14, 1957, by S. D. Van Gundy.

The two additional new species described here are represented by females only. One was collected by W. H. Hart of the Bureau of Plant Pathology, California State Department of Agriculture, on June 2, 1953, from soil taken on the bank of an intermittent stream near Loomis, Calif. These nematodes are different from all other members of *Hemicycliophora* because of the distinctly separated annules of the lip region. The other new species is based on specimens furnished by M. W. Allen from the University of California Nematode Survey Collection. This material was taken from soil about the roots of tules on Jan. 9, 1954, near Antioch, Calif.

Hemicycliophora epicharis, n. sp. (Fig. 1, A-E)

6 ♀ ♀ : .85-.95 mm. a = 22-27, b = 5.7-6.3, c = 11.0-15.1
V = $^{30\text{-}62}$83-86— Stylet = 69-83 μ
6 ♂ ♂ : .61-.73 mm. a = 29.33, b = ?, c = 8.4, 9.3
T = 23-35% Stylet = lacking

FEMALE (Holotype): .95 mm. a = 25, b = 6.3, c= 13.7, V = ^{43}86—. Body annules coarse, approximately 5-6 μ wide, total number 164. Larval cuticle very thick, fits loosely about body. Lateral field not observed on adult; on larval cuticle the lateral field shows as interruptions of annulation (Fig. 1, E) which result from anastomosis of annules. Lip region bluntly rounded, bearing two annules. Spear 83 μ long, extends through 16 annules, prorhabdion 67 μ long, basal knobs directed somewhat posteriad. Hemizonid obscure, approximately one body annule in width immediately anterior to excretory

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pore. Excretory pore 169 μ from anterior end, about 4 annules posterior to beginning of intestine. Uterus with prominent spermatheca. Vulva deeply indented, overlapped 28 μ by cuticular fold. Posterior lip of vulva bearing a distal process somewhat resembling the structure on spicular sheath of male. Anus located on 16th annule from terminus. Body tapers at first very slightly posterior to vulva then more abruptly to form a bluntly conoid tail with rounded terminus.

Male (Allotype): .69 mm. a = 33, b = ?, c = 8.9, T = 29%. Body slender, cylindroid, tapering anteriad and posteriad. Annules fine, approximately 2 μ wide. Lateral field marked by 4 lines. Lip region well set off, hemispherical and without annulation. Stylet lacking. Esophagus degenerate. Excretory pore 131 μ from anterior end. Hemizonid about 2 annules wide located 2 annules anterior to excretory pore. Spicules semi-circular, measuring 48 μ along arc. Spicular sheath 14 μ long, bears hamate process on distal, posterior edge. Gubernaculum simple, 9 μ long. Caudal alae broad, about 3 times as long as body width. Tail tapers gradually from cloaca to bluntly rounded terminus.

Holotype: Female collected Feb. 4, 1956, by writer. Catalogue number 110 University of California Nematode Survey Collection, Berkeley.

Allotype: Male, same data as holotype. Catalogue number 111 University of California Nematode Survey Collection, Berkeley.

Paratypes: 5 females, 5 males, same data as holotype, deposited in University of California Nematode Survey Collection, Berkeley.

Type Host: Soil about roots of cajeput, *Melaleuca leucadendra* L.

Type locality: Approximately 5 miles east of Lakeland, Florida, on U. S. Highway 92.

Diagnosis: *Hemicycliophora epicharis* most closely resembles *H. brevis*, from which it can be distinguished by the longer spear and single line in the lateral field of females of *brevis*. In addition the females of *brevis* have a greater total length than those of *epicharis*.

H. epicharis females are similar to *H. typica* from which they can be distinguished by the fewer and larger annules, the blunter tail and the shorter spear. Also, the males of *epicharis* are shorter, have 4 lines in the lateral field, a shorter, blunter tail, and a longer spicular sheath.

Hemicycliophora vidua, n. sp. (Fig. 1, F-G)

9 ♀ ♀ : 1.12-1.33 mm. a = 26-31, b = 5.4-6.2, c = 9.0-9.3
V = $^{35\text{-}49}$78-80— Stylet = 112-122 μ

Female (Holotype).—1.33 mm. a = 29, b = 5.8, c = 9.3, V = ^{35}80—. Body annules 348 in number, approximately 4 μ wide. Larval cuticle fits rather closely except on tail. Lateral field not observed on adult; on larval cuticle the lateral field shows interruptions due to anastomosis similar to that shown in Fig. 1, E. Lip region rounded, bearing 2 annules, lightly sclerotized. Spear 122 μ long, extending through 39 annules, prorhabdion 102 μ, basal knobs rounded and directed somewhat posteriad. Hemizonid approximately 2 annules wide located one or two annules anterior to excretory pore. Excretary pore on 67th annule, 213 μ from anterior end, located slightly anterior to beginning of intestine. Vulva with slightly protuberant lips. Anus obscore, located on approximately the 46th annule from terminus (exact count not possible due to obscure annulation near terminus). Tail convex-conoid, somewhat attenuated to a very finely rounded terminus.

Male: Not known.

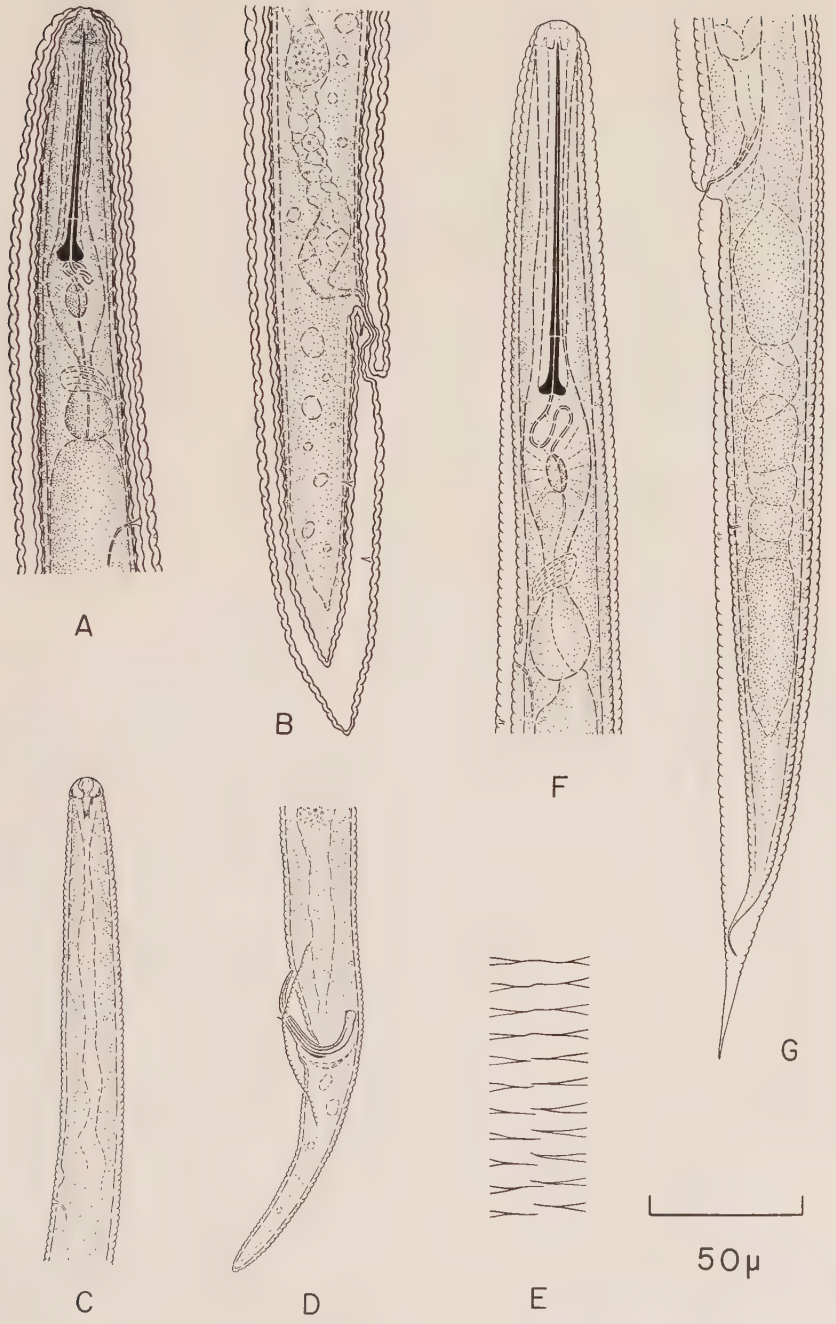

Fig. 1. *Hemicycliophora epicharis.* A, B. Anterior and posterior portions of female, C, D. Anterior and posterior portions of male. E. Lateral field of larval cuticle on female. *Hemicycliophora vidua.* F, G. Anterior and posterior portions of female.

HOLOTYPE: Female collected Jan. 9, 1954, by Paul Hurd. Catalogue number 112 University of California Nematode Survey Collection, Berkeley.

PARATYPES: 10 females, same data as holotype, deposited in University of California Nematode Survey Collection, Berkeley.

TYPE HOST: Soil about the roots of tules.

TYPE LOCALITY: Near Antioch, California.

DIAGNOSIS: *Hemicycliophora vidua* resembles *H. gracilis,* from which it differs in the shorter length of the females and absence of the two longitudinal lines in the lateral field of the larval cuticle. In addition the excretory pore is located near the end of the esophagus in *vidua* and about one body width posterior to the esophagus in *gracilis. H. vidua* keys out to *H. similis* in Thorne's key (1955) but differs from this species in the length of spear, which ranges from 112-122 μ in *vidua* and 90-104 μ in *similis.* The tail of *vidua* is more attenuated and the body posterior to the vulva is 6.6-7.8 times the body width at the vulva. In *similis* the body length posterior to the vulva is 5.3-6.4 times the body width at the vulva.

Hemicycliophora brevis Thorne, 1955 (Fig. 2, E-G)

3 ♀♀ : .88-1.08 mm. a = 19-26, b = 4.6-5.3, c = 16-18
V = $^{38\text{-}70}$87-90— Stylet = 116-120 μ
6 ♂♂ : .78-.84 mm. a = 33-34, b = ?, c = 7.8-9.9
T = 20-28% Stylet = lacking

FEMALE: Body annules coarse, approximately 5-6 μ wide, total number 183-250. Lateral field not observed on adult; on larval cuticle the lateral field generally appears as a single line (Fig. 2, G). Lip region bluntly rounded, bearing 2 annules. Excretory pore 193-223 μ from anterior end. There are 28-36 annules between the vulva and the terminus. Anus located on 18-19th annule from terminus.

MALE: Body slender, cylindroid, tapering anteriad and posteriad. Annules fine, approximately 2 μ wide. Lateral field marked by 4 lines. Lip region slightly set off, hemispherical, without annulation. Stylet lacking. Esophagus degenerate. Excretory pore 151-168 μ from anterior end. Hemizonid approximately 2 annules wide located 4 annules anterior to excretory pore. Spicules semi-circular, measuring 50-55 μ along the arc. Spicular sheath about 14 μ long, bears hamate process on distal, posterior edge. Gubernaculum simple, 10 μ long. Caudal alae broad, about 3 times as long as body width. Tail tapers gradually from cloaca to a rounded terminus.

These specimens were collected by S. A. Sher on July 1, 1957, from soil about the roots of oak on the Bishop Ranch near Santa Barbara, Calif.

Hemicycliophora hesperis, n. sp. (Fig. 2, H-I)

4 ♀♀ : 1.13-1.22 mm. a = ?, b = 6.2-7.3, c = 9.6-10.4
V = $^{31\text{-}39}$84-85— Stylet = 103-109 μ

FEMALE (Holotype) : 1.22 mm. a = ?, b = 7.3, c = 10.4, V = ^{39}85 . Body annules coarse, approximately 4 μ wide, total number 286. Larval cuticle thick, fits loosely about body. Lateral field not observed. Lip region rounded, well set off with 3 distinctly separated annules. Spear 103 μ long, extends through 21 annules (prorhabdion 86 μ long), basal knobs directed slightly posteriad. Hemizonid 1-2 annules wide, one annule anterior to excretory pore. Excretory pore 215 μ from anterior end, approximately one

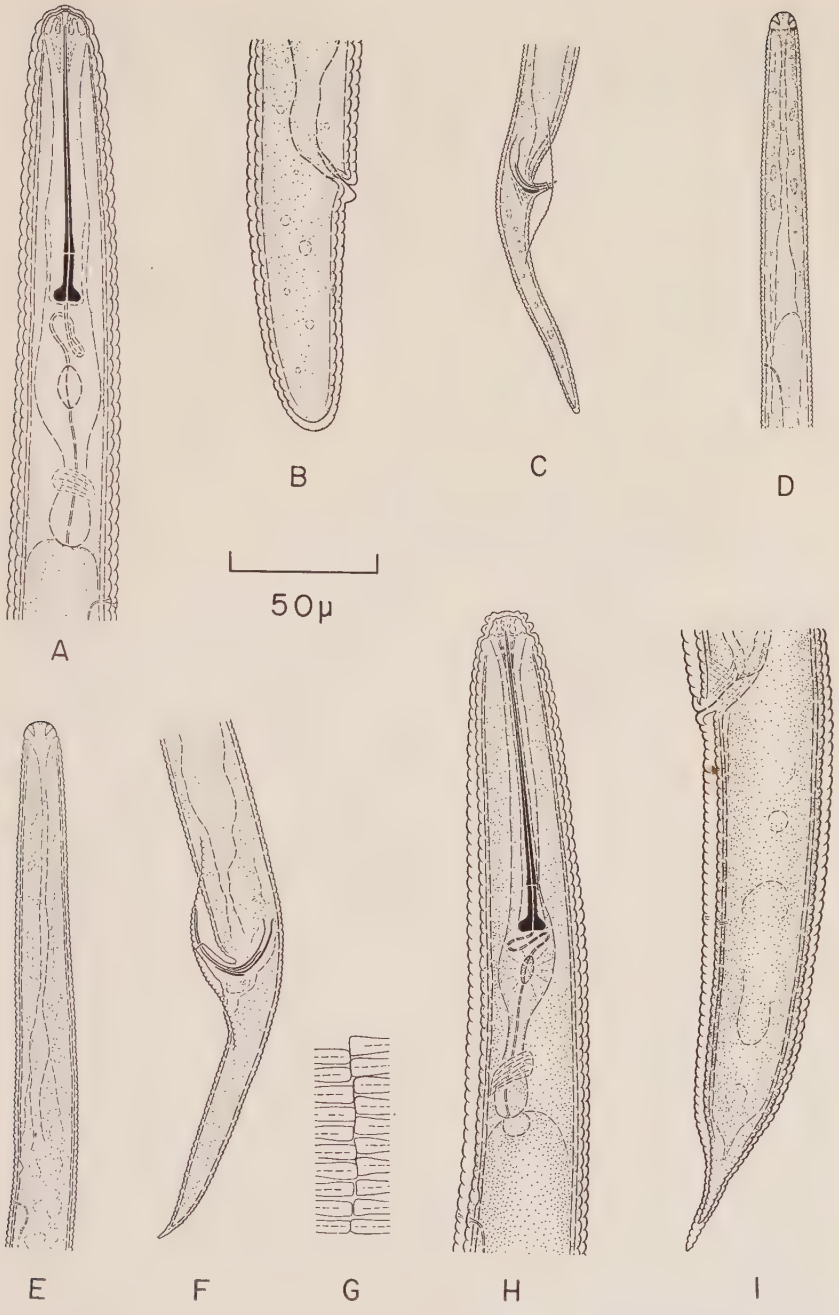

Fig. 2. *Hemicycliophora arenaria.* A, B. Anterior and posterior portions of female. C, D. Posterior and anterior portions of male. *Hemicycliophora brevis.* E, F. Anterior and posterior portions of male. G. Lateral field of larval cuticle on female. *Hemicycliophora hesperis.* H, I. Anterior and posterior portions of female.

body width posterior to end of esophagus. Vulva with slightly protruding lips, 59 annules from terminus. Anus inconspicuous on 39th annule from terminus. Body tapers very slightly up to approximately one body width from end of body, then narrows abruptly, ending in a rounded terminus.

Male: Unknown.

Holotype: Female collected June 2, 1953, by W. H. Hart. Catalogue number 113, University of California Nematode Survey Collection, Berkeley.

Paratypes: 3 females, same data as holotype.

Type host: Soil about roots of many plants, including nutgrass and willow.

Type locality: A small ravine on the property of the California Nursery Co., near Loomis, Placer County, California.

Diagnosis: *Hemicycliophora hesperis* is distinguished from all other members of this genus by the distinctly separated annules of the lip region.

This species was also collected from soil at the roots of live oak near San Mateo, Calif.

Hemicycliophora arenaria, n. sp. (Fig. 2, A-D)

11 ♀ ♀ : .84-.93 mm. a = 20-26, b = 4.8-5.1, c = 14.4-23.6
V = $^{39\text{-}69}$89-92— Stylet = 86-100 μ
17 ♂ ♂ : .53-.74 mm. a = 26-38, b = ?, c = 1.0-9.3
T = 27-46% Stylet = lacking

Female (Holotype): .84 mm. a = 24, b = 4.9, c = 23.6, V = ^{69}92—. Body annules coarse, approximately 5 μ wide, total number 172. Larval cuticle fits closely about body. Lateral field not observed. Lip region of adult bluntly rounded without obvious annulation, covered by 2 annules of larval cuticle. Spear 86 μ long, extends through 20 annules prorhabdion 74 μ long, basal knobs directed somewhat posteriad. Hemizonid not observed. Excretory pore on 35th annule approximately 174 μ from anterior end of body, near junction of esophagus and intestine. Vulva with slightly protruding lips and slight ventral contraction posteriorly, located on 18th annule from terminus. Anus located on 11th annule from terminus. Body almost cylindrical posterior to vulva to broadly rounded almost hemispherical tail.

Male (Allotype): .59 mm. a = 33, b = ?, c = 8.5, T = 46%. Body slender, cylindroid, tapering anteriad and posteriad. Annules fine, less than 2 μ wide. Lateral field marked by 4 lines. Lip region set off, hemispherical, without annulation. Stylet lacking. Esophagus degenerate. Excretory pore 111 μ from anterior end. Hemizonid about 2 annules wide located 2 annules anterior to excretory pore. Spicules semicircular, measuring 28 μ along arc. Spicular sheath 15 μ long, bears hamate process on distal, posterior edge. Gubernaculum simple, 6 μ long. Caudal alae broad, about 3 times as long as body width. Tail tapers gradually from cloaca to rounded terminus.

Holotype: Female collected Oct. 14, 1957, by S. D. Van Gundy. Catalogue number 114, University of California Nematode Survey Collection, Berkeley.

Allotype: Male, same data as holotype. Catalogue number 115, University of California Nematode Survey Collection, Berkeley.

Paratypes: 10 females, 16 males, same data as holotype, deposited in University of California Nematode Survey Collection, Berkeley.

Type host: Rough lemon rootstock, *Citrus limonia* Osbeck.

Type locality: Mecca, California.

DIAGNOSIS: *Hemicycliophora arenaria* differs from all the round tailed species in being the only one for which males are known, in the more posterior location of the vulva, and in the fewer number of annules between the vulva and the terminus. It differs from *obtusa* in the shorter stylet in the female (stylet of *obtusa* is 120 μ); from *nana* in the ventral contraction of body at vulva and in the absence of the third larval skin which persists in *nana;* from *rotundicauda* in the length of adult female (.69-.93 mm. for *arenaria* and 1.20 mm. for *rotundicauda*).

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Resistance of Cattle to Infection with *Cooperia punctata*

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Bailey (1949) showed in a controlled test that calves up to 12 months of age demonstrated no age resistance to experimental infection with the intestinal nematode, *Cooperia punctata*. He also showed that calves may go through a self-cure similar to that described in sheep (Stoll, 1929) infected with *Haemonchus contortus*.

The present observations were made to investigate further the nature of this acquired resistance.

MATERIALS AND METHODS

Four grade Jersey steers ranging in age from 19 to 26 months were used. These animals had grazed 11 months on pastures on which they were exposed to and acquired *C. puntata* infections. They were removed from pasture and placed in stanchions in a concrete-floored barn. Twenty-four hours later, each animal was given by mouth 1 million infective larvae of *C. punctata* in water. Daily fecal samples were taken thereafter until the animals were slaughtered. Post-mortem examinations were conducted on the third, sixth, ninth, and twelfth days after the administration of larvae.

On post-mortem, aliquots representing 1/40th and 1/30th of the intestinal and abomasal contents, respectively, were examined. The remaining contents of the small intestine were baermannized to recover as many larvae as possible.

RESULTS

Live ensheathed infective-stage larvae of *C. punctata* were recovered by zinc sulfate flotation from the feces of all the animals on the first day after larval administration. No larvae had ever previously been recovered from the feces of any of these animals. The average number was 5.5 larvae per gram of feces. Using Stoll's formula (1936), 20 times the animals weight in pounds, to approximate the number of grams of feces passed in 24 hours, it was estimated that the animals passed an average of 46,750 larvae.

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No larvae were detected in fecal samples collected after the first day.

Larvae were recovered from the alimentary tract of the animals autopsied at 3, 6 and 9 days after infection, but not from that of the animal killed 12 days after infection.

An estimated 4,100 third-stage larvae (0.4% of the number given) were recovered from the steer killed 3 days after drenching. Two-thirds of them were found in the abomasum and were developing normally, being in an advanced phase of this stage. Some of the remaining third, recovered from the small intestine, had also exsheathed but apparently had not increased in length, whereas others had not exsheathed as yet.

No larvae were recovered from the aliquots taken from the stomach and small intestine of the steer killed 6 days after drenching, and only approximately 40 third-stage ensheathed larvae were recovered by baermannization of the intestinal contents. However, an estimated 600 third-stage ensheathed larvae were recovered from the steer killed 9 days after drenching, all from the stomach.

Discussion and Conclusions

In a previous investigation Stewart (1954) recovered no ensheathed larvae from the intestines of worm-free calves 2 days after the animals were given infective larvae of *C. punctata,* nor were larvae recovered from the stomach later than 1 day after the administration of larvae. Therefore, the results presently reported indicate that the acquired resistance of these four experimental animals was inhibitory to the exsheathing and further development of most of those larvae of *C. punctata* that did not pass out of the digestive tract within the first 24 hours after administration to the host animals. The fact that some normally developing larvae were recovered only from the animal killed 3 days after infection may indicate that no development beyond the third stage was possible in these animals. In normal calves, Stewart (*loc. cit.*) reported the finding of fourth-stage larvae 4 days after infection. In no case were fourth-stage larvae found in the present series.

That the resistance of the host may also prevent the infective larvae of this parasite from passing normally into the intestine from the abomasum was evidenced by the finding of ensheathed third-stage larvae in the abomasum of the steer killed 9 days after administration of larvae.

Summary

The acquired resistance of steers to *Cooperia punctata* was inhibitory to the exsheathing and further development of larvae of *C. punctata.* The resistance may also sometimes manifest itself by preventing larvae from passing normally from the abomasum into the small intestine.

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On the Morphology of the Coffee Root-Knot Nematode, *Meloidogyne exigua* Goeldi, 1887*

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The first record on nematodes attacking roots of coffee trees in Brazil was published by Jobert in 1879. Some years later, Goeldi (1887) stated that the primary cause of a disease affecting coffee plantations at the so-called Province of Rio de Janeiro was the nematode referred to by Jobert. At that time, Goeldi erected the new genus *Meloidogyne,* and described *Meloidogyne exigua* as the type species. Since then, authors have made references to root-knot nematodes found infecting coffee trees in several South American countries, and in the U. S. A., at the New York Botanical Garden (Chitwood, 1949; Lordello, 1953; Taylor, Dropkin & Martin, 1955; etc.). In 1949, Chitwood published his well-known paper on the root-knot nematodes, proposing the revalidation of the genus *Meloidogyne,* which had been synonymized with *Heterodera* Schmidt, 1871 by previous authors.

Recently, the writers examined roots of coffee trees grown in the Ribeirão Prêto area, in the State of S. Paulo, Brazil, and found *M. exigua* attacking all the decaying plants. Experiments for recuperating old coffee orchards have been conducted at one of the plantations infected by *M. exigua,* but the trees did not respond as expected. Actually, preliminary surveys suggest that *M. exigua* is an important detriment to coffee production in the Ribeirão Prêto region. *M. exigua* produces somewhat small galls on the roots of coffee trees. These galls may be easily overlooked, particularly if the material collected is not protected against desiccation. Necrotic areas are also to be seen on the roots. The trees found infected belong to the following varieties of *Coffea arabica* L.: red Bourbon, yellow Bourbon and "Mundo Novo."

M. exigua is a little known root-knot nematode species. The description by Goeldi is adequate to place the genus, but is erroneous in many respects. In addition, Chitwood could not give an entirely satisfactory redescription because the material he had for study was in poor condition. For those reasons, the observations carried out with the abundant material collected at Ribeirão Prêto are here presented as a contribution to the knowledge of *M. exigua,* the coffee root-knot nematode.

Meloidogyne exigua Goeldi, 1887

EGGS: The eggs are ellipsoidal, 73.4-88.7 microns long and 38.3-44.4 microns wide (fig. 1, J). Observation made on eggs containing larvae did not offer any indication that the first larval moult takes place inside the egg.

PREPARASITIC LARVAE: The worm shaped body tapers to both extremities, more sharply posteriorly, ending in an elongated tail. Head bearing one post labial annule; stylet bulbs weakly developed and rather compressed longitudinally. Cuticle annulated, the annulation being much less evident than in adults. Middle bulb of oesophagus ovoid. Oesophageal glands rather long (fig. 1, H, and I). The nerve ring encircles the oesophageal isthmus just below the middle bulb. Intestinal cells filled with coagulated substances, forming

*The authors wish to express their best thanks to Dr. Hermano V. de Arruda, of the Estação Experimental de Ribeirão Prêto, S. Paulo, Brazil, who supplied them with several samples of roots of coffee trees disfigured by *M. exigua.*

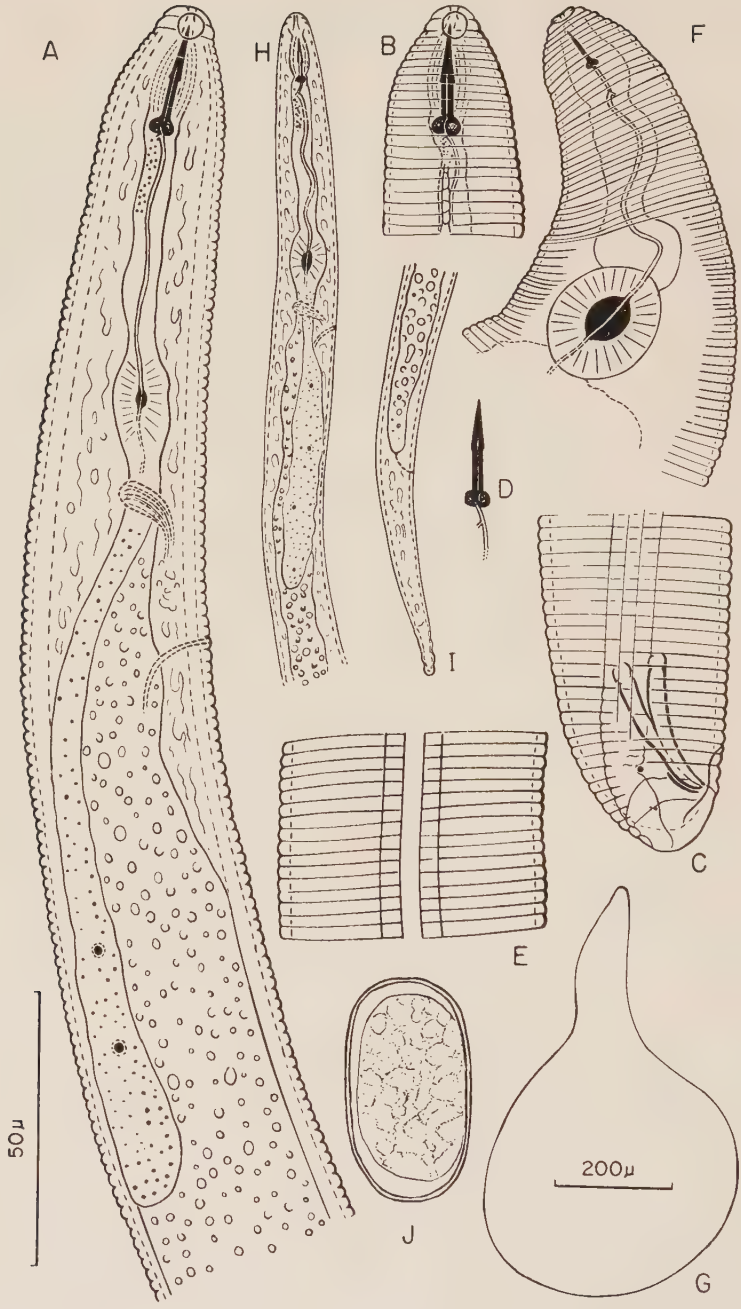

Fig. 1.—*Meloidogyne exigua* Goeldi, 1887: A. Oesophageal region of the male; B. Head of the male; C. Posterior end of male; D. Stylet of male; E. Lateral field of male; F. Oesophageal region of the female; G. Form of the female body; H. Oesophageal region of preparasitic larva; I. Posterior end of preparasitic larva; J. Egg.

more or less round and characteristic bodies. Anal opening sometimes hard to locate. Phasmids not seen. Lateral fields 3.1 microns wide, made up of four incisures.

Measurements (in microns). Length: 333.5-358.0; width: 13.7-15.3; tail: 44.4-46.0; stylet: 9.2; middle bulb of oesophagus: 10.7 x 7.7; length of oesophagus: 78.0-82.6; anal diameter: 7.7-9.2; a = 22.2-26.0; b = 4.2-4.4; c = 7.3-7.8.

FEMALE: The whitish females have well defined neck and were obtained from the smooth-walled cavities of the root tissues (fig. 1, G). A number of dead females was also obtained during dissection of the galls. These females were violaceous in color and had rather resistant cuticle, looking like wall of cysts of the *Heterodera* species.

Head pointed, stylet straight or slightly curved, provided with small knobs. Canal of the oesophagus strongly walled from the beginning of the organ until it enters the valves of the middle bulb, where it becomes rather weak. A constriction of the surrounding tissues is seen at the point of union of the oesophageal canal with the middle bulb, the latter being ovoid to spherical and quite strong (fig. 1, F). Lateral fields and excretory pore not

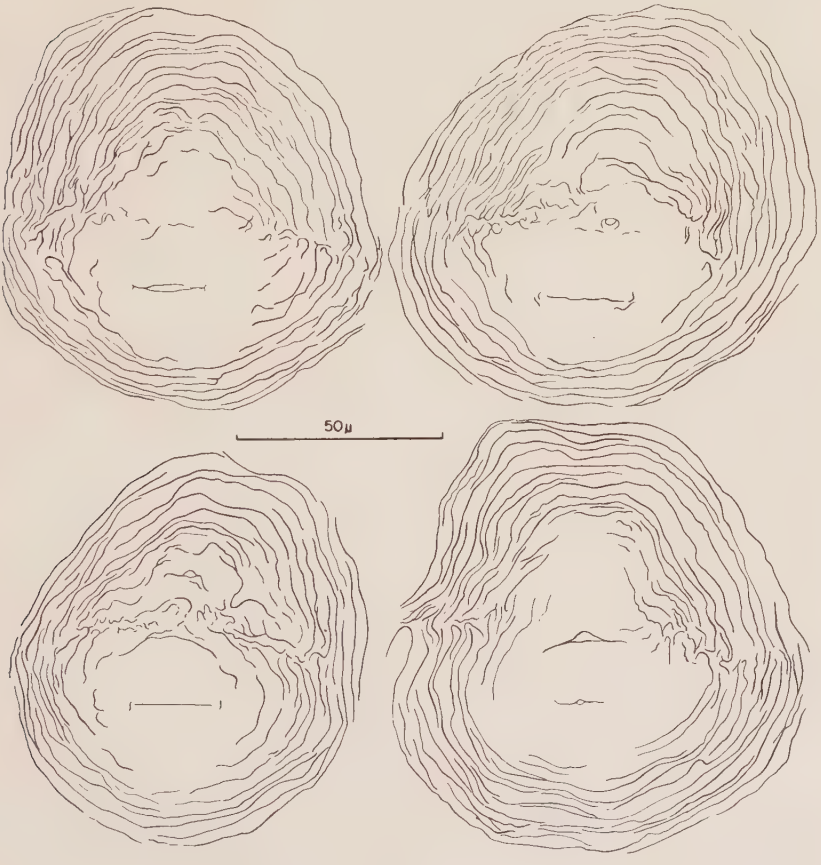

Fig. 2.—*Meloidogyne exigua* Goeldi, 1887: Perineal patterns of adult females.

seen. Ovaries convoluted, usually filled with oocytes. The perineal pattern agreed with that figured by Chitwood (1949) and Taylor, Dropkin & Martin (1955) for the species. The arch is low and slightly flattened and the lateral lines poorly defined and bordered by folded and broken striae (fig. 2).

Measurements (in microns). Length: 387.5-496.0; width: 279.0-372.0; stylet: 10.7; distance from the orifice of the dorsal gland to base of stylet: 4.6-7.7; oesophagus middle bulb: 30.6-33.6 x 24.5-26.0.

MALE: Body worm-like in shape, tapering more abruptly toward anterior end. The head, more frequently obtained in lateral or sublateral view, is slightly set off from neck. Labial annule wide and rather flat in lateral view; post labial annule without any striation in dorso-ventral, as well as in lateral view. Cuticle strongly annulated. Lateral fields beginning a little back of the level of the stylet knobs and extending to tail end. They are usually made up of four incisures, but in several males additional incisures were counted. The transverse striae of cuticle may cut the outer bands of the fields, as illustrated (fig. 1, E). At about the middle of the body, the fields are 7.6-9.2 microns wide.

Meloidogyne males usually have a twisted body. *M. exigua* males, however, are not twisted, thus constituting an exception among the root-knot nematodes already studied by the writers. Actually, other species previously investigated have males to which the twist of the body was calculated to be 90 degrees (Lordello, 1956, and 1956a). Twisting may be considered as being adaptative in character, since it is supposed that the males have to roll their body around the female body when copulation takes place.

Stylet strong, the knobs being ovoid and very pronounced. The nerve ring encircles the isthmus just below the middle bulb (fig. 1, A). Intestinal cells filled with coagulated bodies of different forms. Excretory pore well defined, located at 96.0-130.0 microns from the head end. All the males studied have two well developed testes, which may be reflexed or completely outstretched, usually reaching the oesophageal region. Spicules arcuated ventrally; gubernaculum well defined. Phasmids very small (fig. 1, C).

In the population handled, two types of males were found, which differed in the distance between the opening of the dorsal oesophagal gland and the stylet knobs. In one type, that distance is around 3.0 microns, while in the other the orifice is too close to the knobs to measure. Since no differences were observed in the other stages of the parasite, the two male types were considered as individual variations within the same species (fig. 1, B, and D).

In lateral and sublateral views, the *ampulla* of the amphids may be more or less easily located, due to its circular outline. The writers prefer to use the term *ampulla* for such amphidial structure in the genus *Meloidogyne,* instead of the word "cheek" introduced by Chitwood (1949) which, according to the writers' opinion, is quite inadequate. As already shown by Allen (1952), Cobb (1924) did not use the word "cheek" to designate the organ mentioned above, but stated that "the amphids are protected by cheeks." As Allen (1952) does, the writers understand that Cobb referred to the well developed lateral lips of the *Meloidogyne* species.

Measurements (in microns). Length: 832.3-1,092.4; width: 26.0-46.0; stylet: 18.4-19.9; distance from the opening of the dorsal gland to base of stylet: 0.0-3.0; stylet knobs: 4.0-6.1 x 3.0; middle bulb of oesophagus: 15.3 x 9.2; tail: 6.1-10.0; spicules (measured on chord of their arc): 20.0-26.0; gubernaculum: 7.7; height of head: 3.1-4.6; a = 23.8-32.0; b = 8.1-8.9; c = 95.8-110.0.

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Alkaline Phosphatase in the Trematode Excretory System*

WILLIAM H. COIL

The function of the excretory system among the platyhelminth worms is yet to be understood; however, both Beaver (1929) and Willey (1934) have published notes on the morphology of the flame cells in trematodes. There are good reasons to believe that this system functions in both osmoregulation and excretion. Kromhout (1943) showed that, in the case of the turbellarians, the excretory system is most highly developed in the fresh water forms and least in the marine species. On the other hand, Buchanan (1931) found that turbellarians gain weight by imbibition in distilled water and lose weight in salt water, thus showing that this system can be overworked under extreme conditions. In contrast to this, many trematodes can pass from fresh water to solutions with various osmotic pressures during the various stages of their life cycles. The motion of the flame cells can be stimulated by saline (Beaver 1929) or urine. This could be either a response to the ions of different inorganic salts or a response to an osmotic change. The presence of concretions in the excretory bladders of some trematodes would lead one to believe these are the result of excretory action.

Several years ago when I was attempting to work out the complex excretory system of some gorgoderid trematodes, it occurred to me that there must be an easier way than the study of living material. This led to the speculation that alkaline phosphatase, present in the excretory systems of many other animals, might be present in the excretory system of trematodes. At that time this postulate was tested, but for some reason, unknown to me, no evidence was found to support it. Recently, while studying a gorgoderid cercaria (close to *Cercaria sphaerocerca* Miller, 1936) from the gills of a sphaeriid bivalve, it was noted that the daughter sporocysts possessed unusually large flame cells and associated capillaries. It was thought that this large material might work better than previous specimens.

The living material was fixed in chilled acetone (below 0°C) and then placed, in acetone, in a refrigerator for 24 hours. Imbedding was carried out

*From the Department of Zoology, University of Nebraska. Study No. 303, supported by a Grant-in-Aid from the University of Nebraska Research Council.

in 56°C wax with the heat of a lamp adjusted so the tissues were at the interface of the melted and solid wax. Sections were cut at eight microns and they were placed on slides without albumin fixative. After drying, the sections were treated with Gomori's modified technique (Glick, 1949). An incubation of two hours at 37°C was found to give good results. Control slides were made by (1) passing sections through all solutions except the substrate and (2) by reducing the incubation time and noting the comparative amount of precipitate formed.

The highest activity was found in the capillaries leading from the flame cells (figure 1). The activity is sharply delimited to the wall of the capillary (cross section in figure 1). The flame cell itself shows some activity, mainly in the structure which produces the flame-like appearance (figure 2). Alkaline phosphatase has frequently been found in high concentrations in the secretory or absorptive surfaces of various animal organs (vertebrate kidney, intestine, gills and gall bladder of marine fishes, and cuticle of tapeworms and acanthocephala). Although there is no direct evidence that phosphatase is involved in secretory or absorptive function, there is a positive correlation between the quantity of the enzyme and these functions. The present findings suggest that the flame cell and its associated capillary may similarly function in selective transfer of chemical substances.

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Figure 1. Photomicrograph of cross section of capillary leading from a flame cell.

Figure 2. Photomicrograph of a flame cell and associated capillary.
Scale equals 0.01 mm.

Nomenclatorial Notes on the Genus *Criconemoides* (Nematoda: Criconematidae) with a Key to the Species

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Ten new species of nematodes were described by Kir'ianova (1948), three of them in the genus *Ogma* and seven in the genus *Criconema*. The first three were transferred to the genus *Criconema* by Chitwood (1957). The seven species described in the genus *Criconema* by Kir'ianova properly belong in the genus *Criconemoides*. As a consequence of this transfer the species described as *cylindricum* by Raski, 1952 becomes a secondary homonym of *Criconemoides cylindricum* (Kir'ianova, 1948) and a new name is proposed here for the former. In addition, *Hoplolaimus zavadskii* described by Tulaganov in 1941 most closely resembles *Criconemoides parvum* Raski, 1952 and also should be placed in the genus *Criconemoides*.

Specimens have not been available for comparative studies but the descriptions and illustrations provide an adequate morphological basis to distinguish these eight species from other described species. It is notable that paired, anteriorly directed gonads are described for *C. tenuicute* since a single ovary is characteristic of all other species in the subfamily Criconematinae. The large, oval amphids described and illustrated for *C. tulaganovi* and *C. beljaevae* are also very unusual in this genus. Heretofore the amphids of *Criconemoides* species have been represented at most by narrow, slit-like or small, oval apertures located close to the oral opening. These species are, however, similar in all other morphological characteristics to the *Criconemoides* and the following nomenclatorial changes are proposed:

Criconemoides ornatum Raski *nomen novum pro*
C. cylindricum Raski, 1952 (*nec* Kir'ianova, 1948)

Criconemoides cylindricum (Kir'ianova, 1948) n. comb.
Synonym: *Criconema cylindricum* Kir'ianova, 1948
Type habitat: Soil about *Juniperus excelsa.*
Type locality: Government Nikitsy Botanical Garden, SSR.

Criconemoides zavadskii (Tulaganov, 1941) n. comb.
Synonym: *Hoplolaimus zavadskii* Tulaganov, 1941
Type habitat: Soil about cotton plants.
Type locality: Samarkand, Uzbeck, SSR.

Criconemoides anura (Kir'ianova, 1948) n. comb.
Synonym: *Criconema anura* Kir'ianova, 1948.
Type habitat: On roots of grasses.
Type locality: 40 kilometers south of Mount Vishera, near Torbino, Leningrad District, SSR.

Criconemoides quadricorne (Kir'ianova, 1948) n. comb.
Synonym: *Criconema quadricorne* Kir'ianova, 1948
Type habitat: Soil from field of summer wheat.
Type locality: Shatilovsky Exp. Sta., Orlovsky Region, SSR.

Criconemoides beljaevae (Kir'ianova, 1948) n. comb.
Synonym: *Criconema beljaevae* Kir'ianova, 1948
Type habitat: Soil of cotton fields.
Type locality: Sci. Research Inst. Sta., Tashkent, SSR.

Criconemoides tulaganovi (Kir'ianova, 1948) n. comb.
Synonym: *Criconema tulaganovi* Kir'ianova, 1948

Type habitat: Soil from tomato fields.
Type locality: Kolkhoz Neurne, near Poti, SSR.

Criconemoides pullum (Kir'ianova, 1948) n. comb.
Synonym: *Criconema pullum* Kir'ianova, 1948
Type habitat: Soil from fields of winter wheat.
Type locality: Shatilovsky Exp. Sta., Orlovsky Region, SSR.

Criconemoides tenuicute (Kir'ianova, 1948) n. comb.
Synonym: *Criconema tenuicute* Kir'ianova, 1948
Type habitat: Soil.
Type locality: Near Orsk, Chalilovsky District, SSR.

KEY TO THE SPECIES OF *Criconemoides*

1. Spear length 90 microns or less 5
   Spear length 100 microns or more 2
2. Total body annules 95 or more 3
   Total body annules 58-61 ..... *annulifer* (de Man)
3. Length .45 mm. or more; spear not very long and thin (less than ⅓ of body length) 4
   Length .27-.30 mm.; spear very long and thin (more than ⅓ of body length) ..... *macrodorum* Taylor
4. Spear 105 microns; total body annules 140; length .88-1.00 mm. ..... *annulatum* Taylor
   Spear 122 microns; total body annules 95-103; length .46 mm. ..... *sphagni* (Micoletzky)
5. Tail rounded 11
   Tail pointed 6
6. Total body annules less than 80 8
   Total body annules 110 or more 7
7. Length .70 mm.; vulva on 16-17th annule from terminus ..... *komabaënsis* (Imamura)
   Length .55-.59 mm.; vulva on 8th annule from terminus ..... *morgense* (Hofmänner and Menzel)
8. Total body annules 70 or more 9
   Total body annules 65 ..... *heideri* (Stefanski)
9. Vulva located on 12-15th annule from terminus; total body annules 70-76 10
   Vulva located on 7th annule from terminus; total body annules 79 ..... *peruense* (Steiner)
10. Length .70 mm.; first annule larger than second annule ..... *crotaloides* (Cobb)
    Length .40-.49 mm.; first annule smaller than second annule ..... *demani* (Micoletzky)
11. No joints on lateral line, annules unbroken except occasional anastomosis 14
    Joints on lateral line except on anterior end of body 12
12. Lateral line zig-zag; spear 57 microns or more 13
    Lateral line with simple breaks; spear 50 microns ..... *citri* Steiner
13. Length .30 mm.; spear 57 microns; annules 68-72 ..... *sphaerocephalum* Taylor
    Length .50 mm.; spear 85 microns; annules 89 ..... *cylindricum* (Kir'ianova)

14. Total body annules 115 or less; spear 48 microns or more 16
Total body annules 142 or more; spear 25-41 microns 15

15. Total body annules 142-156, angular on posterior edge; vulva on 11-12th annule from terminus ..... *parvum* Raski
Total body annules 200, rounded edges; vulva on 7-8th annule from terminus ..... *zavadskii* (Tulganov)

16. Total body annules 70 or more 18
Total body annules 60-65 17

17. First annule irregular in outline or divided into 4 indefinite sublateral lobes; anus located on 3rd or 4th annule from terminus ..... *informe* (Micoletzky)
Lips 6, large; anus on last annule very near terminus ..... *anura* (Kir'ianova)

18. Spear length 48-67 microns 23
Spear length 70-86 microns 19

19. Sublateral lobes absent 21
Sublateral lobes present 20

20. Head bluntly rounded; amphids narrow, slit-like ..... *xenoplax* Raski
Head sharply tapered; amphids small, rounded ..... *quadricorne* (Kir'ianova)

21. Total body annules 73-84; length .53-.72 mm. 22
Total body annules 106-113; length .34-.42 mm. ..... *teres* Raski

22. Length .53 mm.; total body annules 73 ..... *congolense* (Stekhoven and Teunissen)
Length .72 mm.; total body annules 84 ..... *beljaevae* (Kir'ianova)

23. Sublateral lobes absent, or if present are not prominent and flattened anteriorly 24
Sublateral lobes prominent, flattened anteriorly presenting a truncated head ..... *lobatum* Raski

24. First annule not well set off 25
First annule well set off; cuticle of larvae provided with rows of spines ..... *mutabile* Taylor

25. Length .30-.45 mm.; head and tail not blunt-truncate (tail of *ornatum* somewhat truncate) 26
Length .60 mm.; head and tail both blunt-truncate ..... *rusticum* (Micoletzky)

26. Sublateral lobes absent 28
Sublateral lobes present 27

27. Anterior flap of vulva forming 2 definite points; larvae with longitudinal cuticular fringe; males unknown ..... *ornatum* Raski
Anterior flap of vulva bilobed, rounded; larvae without cuticular markings; males common ..... *curvatum* Raski

28. Lip region plain; amphids small and round or indistinct 29
Head with 6 indistinct lips; amphids large, oval; spear 53 microns; total body annules 70 ..... *tulaganovi* (Kir'ianova)

29. Single gonad; vulva on 5-6th annule from terminus; amphids indistinct ..... *pullum* (Kir'ianova)
Paired gonads; vulva on 8th annule from terminus; amphids small, rounded on 2nd and 3rd annules ..... *tenuicute* (Kir'ianova)

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Report of the Brayton H. Ransom Memorial Trust Fund

FUNDS ON HAND, Jan. 1, 1957	$1766.96
RECEIPTS: Interest received in 1957	59.83
Contribution to principal	5.00
DISBURSEMENTS: Grant to Helminthological Society of Washington	10.00
BALANCE ON HAND, Dec. 31, 1957	1821.70

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MINUTES

Three hundred forty-ninth to the three hundred fifty-sixth meetings

349th meeting: McMahon Hall, Catholic University of America, Washington, D. C., October 16, 1957. Papers presented: Studies on the respiratory physiology of newly hatched and pre-juvenile *Australorbis glabratus*, by von Brand; Cattle dipping in Africa, by Yunker; Problems in cultivation of *Nippostrongylus muris*, by Weinstein; The heritability of DDT resistance in hybrids of Philippine and North American *Culex* mosquitoes, by Rozeboom.

350th meeting: Log Lodge, Agricultural Research Center, Beltsville, Md., November 22, 1957. Slate of Officers for 1958 presented by the Nominating Committee (see Minutes 351st Meeting). Foster gave report of Trustees of the Brayton H. Ransom Memorial Trust Fund; the Trustees voted to reduce annual subsidy of the Proceedings to $10.00. Papers presented: Unidentified growth factors required by *Trichomonas gallinae*, by Shorb and Lund; Immunization against the cattle lungworm, *Dictyocaulus viviparus*, Resistance produced by initial infection with small doses of larvae, by Weber and Lucker; Relative decline in population of viable cecal worm eggs and histomonads on soil under experimental conditions, by Lund; Piperazine citrate as an anthelmintic for removal of the ascarid, *Ascaridia columbae* from pigeons, by Wehr; Parasitic granuloma in the Townsend mole, by Jellison and Hadlow (read by McIntosh); Observations on the effect of stilbestrol on internal parasites of beef cattle, by Vegors.

351st meeting: Biology-Greenhouse Building, Howard University, Washington, D. C., December 13, 1957. The slate of officers presented by the nominating committee was elected for 1958: John S. Andrews, President; Lloyd E. Rozeboom, Vice President; Edna M. Buhrer, Corresponding Secretary-Treasurer; Recording Secretary, M. S. Briscoe. President Andrews appointed

IN MEMORIAM

Robert Thompson Young, Sr.

February 14, 1874—December 6, 1957
Member Helminthological Society of Washington since December 1952

Edward George Reinhard

October 20, 1899—January 29, 1958
See page 73

George W. Luttermoser Executive Committee Member-at-Large. Clark P. Read elected a member of the Editorial Committee. Society informed of the death of Dr. Robert Young. Papers presented: The National Filarial Program in India, by Beye; The occurrence of blood protozoa in North American birds, by Herman; Clinical and laboratory data on a case of congenital toxoplasmosis, by Kayhoe and Jacobs.

352nd meeting: Silvester Hall, University of Maryland. College Park, Md., January 15, 1958. Voted to submit to the American Society of Parasitologists a statement of protest drafted by the Bacteriology Seminar Group of the Agricultural Research Center against salary discrimination by the Civil Service Commission. Papers presented: An expanding Institute of Acarology, by Wharton; Histological observations on the pathogenesis of knemidokoptic mange in parakeets, by Yunker; Systematic characteristics of larval ticks, by Clifford; Some trematodes of Philippine food fishes, by Velasquez; Observations on the biology of *Ornithodoros kellyii*, by Sonenshine; Color as an index to the relative humidity of plaster paris cultures, by Huber. Exhibits demonstrated by the department of Zoology.

353rd meeting: Walter Reed Army Institute of Research Building, Room 341, Washington, D. C., February 26, 1958. Voted to accept financial report of Treasurer. Recommendation made that members of the Society be accorded publication privileges in the Proceedings as in the past. President Andrews

reported the death of Dr. Edward G. Reinhard. Thirty dollars voted to support the Annual Science Fair. Papers presented: Notes on the life cycle of *Dirofilaria uniformis* Price and transmission to laboratory rabbits, by Bray and Walton (read by McMullen); Vital staining of blood parasites, by Rothstein; A field test with four molluscicides against *Oncomelania nosophora* in a terraced hill habitat, by Moon; Results obtained in preliminary prophylactic and chemotherapeutic experiments with a new drug on *Schistosoma mansoni*, by Bruce; Chemotherapeutic experiments with *Clonorchis sinensis*, by Duxbury.

354th meeting: Wilson Hall, National Institutes of Health, Bethesda, Md., March 28, 1958. Reported that the Section on Nematology, USDA, would be host for the picnic May 24, 1958, at Log Lodge. Voted to use $20.00 from general fund of the Society to defray picnic expenses. Papers presented: Pyrimethamine or chloroquine in table salt as a suppressive against malaria, by Coatney and Mickelsen; A new bacterial growth factor, by Greenberg; Observations on the polysaccharides of some aquatic snails, by McMahon, von Brand, and Nolan; Free-living amebae as contaminants in monkey tissue culture, by William G. Jahnes.

355th meeting: Johns Hopkins University, School of Hygiene and Public Health, Baltimore, Md., April 25, 1958. Additional $5.00 voted from general fund of the Society to defray picnic expenses. Foster elected member of Executive Committee. Papers presentd: Hormonal control of ovarian development in the *Culex pipiens* complex of mosquitoes, by Larson; The comparative physiology of tapeworm excystment, by Rothman; The role of inherited antibody in experimental disease in chick embryo, by Borsos; Infection of mosquitoes and bats with Japanese B encephalitis virus, by Lamotte; The effect of testosterone on the sex of accessory glands of starlings, by Hilton.

356th meeting: Log Lodge, Agricultural Research Center, Beltsville, Maryland. Shorb, who had been selected to judge parasitological exhibits at the Science Fair Competition in the Washington Area, April 19, 1958, reported there were no parasitological projects entered. The Editorial Committee reported that the July 1958 issue of the Proceedings would be dedicated to the late Dr. Edward George Reinhard. A picnic followed the business meeting.

The following members were elected to membership during the year: 349th meeting—none; 350th meeting—Luther W. Baxter, Jr., Edward F. Daly, George Garoian, Francis J. Kruidenier, Elliott Lesser, Everett E. Lund, C. Randolph Taylor; 351st meeting—Duane G. Erickson; 352nd meeting—none; 353rd meeting—C. Robert Coatney, Richard C. Fox, Bert Lewengreb, Daniel Sonenshine, Robert L. Watson, Howard A. Winters; 354th meeting—Edward Coleman, Edward W. Lautenschlager, Carmen C. Velasque; 355th meeting—John H. O'Bannion, Ellis E. McCoy, Jr., George J. Rau, Arnold E. Steele; 356th meeting—A. Leslie Neal, L. S. Yeh.

M. S. Briscoe
Recording Secretary

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